SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MAY 1924.

GENERAL PHYSICS.

1048. *Changes of the Torsion Modulus of Eureka Wire when Stretched.* **G. B. Deodhar.** (Zeits. f. Physik, 21. 4. pp. 247–251, 1924.)—The torsion modulus of this metal in wire form has been determined according to known methods. Since stretching influences the torsion modulus in various ways, a study has been made to find how far the different factors alter the elasticity of the wire, and whether any relationship exists between them. Previous work by Harris [see Abstract 5 (1913)] on bismuth wires, and by Sieg on platinum-iridium and tungsten wires [see Abstract 1922 (1922)] is referred to. The torsion modulus η for a copper-nickel alloy (Eureka) is now found to decrease by stretching. Within certain limits the changes can be represented by the formula, $\eta = \mathrm{A}e^{\beta \mathrm{R}}$, where $\mathrm{A} = 5 \cdot 15/10^{-11}$, and $\beta = 1 \cdot 129$. In the first phase, however, the decrease in η is greater than the formula denotes. An explanation of this decrease in the torsion modulus is afforded by a changed crystal structure at the surface of the wire incident on the stretching. The paper contains tables of data, and microphotographs of the metal before and after extension. H. H. Ho.

1049. *The Relation between Elasticity and Internal Pressure.* **K. v. Terzaghi.** (Akad. Wiss. Wien, Ber. 132. 2a. No. 3–4, pp. 105–124, 1923.)—Stress-strain diagrams for plastic materials (*e.g.* clay) will show, if the load is removed and then re-applied, hysteresis loops, and from the slope of the axis of such loops, a modulus of elasticity can be determined. For a given water content, this modulus remains practically constant, whatever the value of the load before removal, but increases as the water content is lessened. E so found is proportional to the pressure which must be applied to reduce the water content to that in the specimen. By means of the ordinary elasticity equations Poisson's ratio can be calculated from the lateral pressure necessary to prevent lateral expansion, and when this is done, for these plastic materials under consideration, values (5·0 for sand, 2·55 for clay) comparable with those of stone and metal are obtained. A value for the internal pressure is deduced, as high as 342 kg./cm.^{2} for one specimen, and this seems to necessitate a much-increased value of the capillary force in the interstices between the particles. If the applied pressure is small compared with this internal pressure, Hooke's law is obeyed by plastic materials, and it is suggested that the rigidity of the substances which obey Hooke's law is only a particular case of the laws found for granular substances. W. G. B.

1050. *Elastic Deformation of a Uniformly Loaded, Contour Supported, Thick Plate.* **C. A. Garabedian.** (Comptes Rendus, 178. pp. 619–622, Feb. 11, 1924.)—The author indicates his method of investigation by the employment of series, as previously applied by him to the investigation of circular plates [Comptes Rendus, 177. pp. 942–944, Nov. 12, (1923)]. He also gives the complete solution for the displacements.

A note by **Mesnager** calls attention to the interest and importance of Garabedian's work. In his own previous work [see Abstract 91 (1918)] he had considered a load at the centre only, owing to the great complication of the analysis for the more general case. Moreover, Navier's investigation, nearly a century ago, obtained solutions only for infinitely thin plates and for thick plates subject to the restriction that the normals should remain rectilinear and normal to the surface throughout the deformation, a condition far removed from reality. G. W. DE T.

1051. *Properties of Celluloid with Reference to Optical Stress-Measurement.* **H. E. L. Martin.** (Univ. of Durham, Phil. Soc., Proc. 6. 5. pp. 323–364, 1922–1923.)—Experiments show that the modulus of elasticity of celluloid is not constant. Strain is a function of time as well as of stress, and a formula is proposed for extension of the form $X = A + Bt^n - f(t)$, where A is the instantaneous extension under a given stress, B is a constant which appears to depend on the difference of stress, n is a constant having an experimental value of 0·365, and $f(t)$ is some function of time. Recovery on unloading follows a different law. Strain is proportional to stress only after equal periods of loading or unloading. The modulus also varies with the previous treatment of the material, variations of 20–30 % being recorded. The optical constants in tension and compression are different and the average value of their ratio is 0·865. The advantages of using mica as the "standard" in stress measurements are pointed out and two methods of doing this are described and compared. The experiments also show that celluloid behaves as a bi-axial crystal. Measurements of its principal indices of refraction are being undertaken. The value in engineering testing of this method of stress measurement depends on establishing accurately the optical properties of strained celluloid. J. V. H.

1052. *Probability Curves Showing Poisson's Exponential Summation.* **G. A. Campbell.** (Bell System Techn. J. 2. pp. 95–113, Jan., 1923.)—In many important practical operations the constant probability of an event happening in a single trial is extremely small, but the number of trials is so large that the event may actually occur a sufficient number of times to become a matter of importance. Curves are now given showing the probability P of such an event happening at least C times in a number of trials for which the average number of occurrences is a. For practical use the question is discussed of what number of trials is necessary to make the curves applicable. Following this comes an investigation of accuracy and of going beyond the curves either in range or accuracy. The results of the mathematical work are summed up in the following formula: For Poisson's exponential binomial limit the average a is expressed as a function of the probability P of at least c occurrences by the infinite series, $a = c\sum_{n=0}^{\infty} Q_n \, . \, c^{-\frac{1}{2}n}$, where the coefficients Q_n are functions of the argument t corresponding to the probability P expressed in the form of the normal probability integral,

$$P = 1/\sqrt{2\pi}\int_{-\infty}^{t} e^{-\frac{1}{2}t^2}dt.$$

A table containing 12 of these coefficients is given, and for any given value of P the corresponding value of t can be found from tables of the probability integral. A very full collection of data accompanies the paper. H. H. Ho.

1053. *Damped Vibrations.* **G. F. Jenkin** and **W. N. Thomas.** (Phil. Mag. 47. pp. 303–306, Feb., 1924.)—The authors point out that the figure illustrating the paper of H. S. Rowell [Abstract 263 (1923)] corresponds to a special case, and show that in a more general case of combined linear and exponential damping, the space-time curve can be plotted as a projection of a composite curve consisting of arcs of a number of equi-angular spirals. W. G. B.

1054. *Practical Approximations to Non-Harmonic Wave Forms of Non-Negligible Amplitude.* **R. Rüdenberg.** (Zeits. Math. u. Mechanik, 3. pp. 454–467, Dec., 1923.)—The author points out that recent developments in many branches of technology call for an exact knowledge of harmonic waves. Moreover, the increase of such knowledge has made it possible either to eliminate the consideration of various phenomena or to utilise them in many ways. In the solution of practical problems we seek, if possible, a linear relation, which may be called the *characteristic*, between the exciting force and the wave form, with the object of approximating to harmonic waves, in which case the natural frequency will be independent of the amplitude. We therefore aim, in the first place, at solving our problems by the consideration only of waves of negligibly small amplitude. But it is often necessary to deal with large, sometimes very large, amplitudes, and in such cases the characteristic will be unobtainable analytically, and we have to be content with a graphical determination. Unless the characteristic be rectilinear the waves will not be simple harmonic, or sinusoidal, as they are frequently called. To begin with, the author considers six examples of vibration of the general type of the ordinary pendulum in which the amplitude is simply neglected, without making the corresponding change in the characteristic which would make the vibration simple harmonic, in order to show how greatly the wave form is changed simply by changing the shape of the characteristic. He then goes on to show by worked-out examples how graphical solutions may be obtained, and considers methods of obtaining approximate solutions in the case of systems disturbed by the action of an external force with a frequency of its own. G. W. de T.

1055. *Precession of Rounded Body Rolling on a Table.* **G. Greenhill.** (Phil. Mag. 47. pp. 94–110, Jan., 1924.)—The author here extends the method employed by him in a paper on the precession of a top spinning about a fixed point [Abstract 1516 (1923)] to the movement of a solid of revolution, free to wander while rolling under gravity, on a horizontal table. The rounded body may, for example, be a coin, plate, canister, wineglass, china egg, or any rounded solid body, so that the experiment is within the reach of all. As before, the treatment adopted dispenses with the use of approximations and proceeds by exact calculation. The discussion is formally limited to the precession in steady motion, and a small nutation superposed, but this does not entirely prevent some brief indications of a wider outlook. G. W. DE T.

1056. *The Motion of Vibrating Bodies in Fluids.* **G. Mayr.** (N. Cimento, 26. pp. 175–189, Oct.–Nov.–Dec., 1923.)—A connected summary of the more reliable work on this subject, both theoretical and experimental. A. Wh.

1057. *Energy Fluctuations from Superposed Periodic Vibrations.* **M. Planck.** (Preuss. Akad. Wiss. Berlin, Ber. 33. pp. 350–354, 1923.)—The problem of finding the statistical energy law in the case of a given number of superposed periodic vibrations of equal energy but with small frequency differences does not seem to have been attacked, probably owing to the difficulties of finding a general solution proving insurmountable. And a solution is required as a necessary preliminary to further advances in the obscure domain of radiation fluctuations. The general problem may be formulated thus: If a given number p of periodic waves, each of energy e and approximately equal frequencies, be superposed, then, in consequence of their mutual interference, energy fluctuations will be set up. The probability that at any given moment the energy fluctuation will lie between E and $E + dE$ will be of the form $W(E)dE$, where $\int_0^\infty W(E)dE = 1$. The solution for $p = 1$ gives a trivial result. For $p = 2$, the two vibrations combine into a periodic wave $E = 4\epsilon \cos^2 \phi/2$, where ϕ is the phase-difference, slowly varying with the time, of the two components. By taking $p = 3$, a reduction formula first appears, which the analysis shows to be developable, as an approximation, into the general form $W_{p+1} = W_p + \epsilon\partial W_p/\partial E + \epsilon E\partial^2 W_p/\partial E^2$, which leads to the general differential equation $(\partial W/\partial\overline{E})_E = (\partial W/\partial E)_{\overline{E}} + E(\partial^2 W/\partial E^2)_{\overline{E}}$, where $\overline{E}$ is the mean energy, from which follows the general expression $W(E)dE = dE/\overline{E} \cdot \epsilon^{-E/\overline{E}}$. G. W. DE T.

1058. *The Heaviside Operational Calculus.* **J. R. Carson.** (Bell System Techn. J. 1. pp. 43–55, Nov., 1922.)—The author has had occasion to make extensive use of Heaviside's methods in electrical problems and here presents a viewpoint which may be as helpful to others as it has been to himself. The Heaviside method is applicable to systems defined by such a set of equations (boundary conditions) as

$$\left.\begin{array}{l} a_{11}x_1 + \ldots a_{1n}x_n = F_1(t) \\ \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \\ a_{24}x_1 + \ldots a_{nn}x_n = F_n(t) \end{array}\right\} \ldots \ldots (1)$$

where the coefficients a_{jk} are in general polynomials of the form $a_{jk} + \beta_{jk}d/dt + \gamma_{jk}d^2/dt^2 + \ldots$, and the α, β, γ coefficients are constants. Then the x's have to be determined as functions of t for the following boundary conditions: The known functions $F_1 \ldots F_n$, and the variables $x_1 \ldots x_n$ are identically zero for negative values of t. That is to say, the system is initially in a state of equilibrium when the *forces* $F_1 \ldots F_n$ are applied, using the term *force* in a generalised form to include electrical, thermal, etc., disturbing actions as well as mechanical forces. The equations being linear, we may, without loss of generality, set all the F functions equal to zero, except one, say, $F_1(t)$. The solutions of these equations may then be made to depend on the auxiliary equations in the auxiliary variables $h_1 \ldots h_n$.

$$\left.\begin{array}{c} a_{11}h_1 + \ldots a_{1n}h_n = 1 \\ \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \\ a_{n1}h_1 + \ldots a_{nn}h_n = 0. \end{array}\right\} \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad (2)$$

The function on the right-hand side, written as unity in accordance with the Heaviside notation, is identically zero for $t < 0$ and unity for $t \geq 0$, and $h_1 \ldots h_n$ are identically zero for $t < 0$. It may then be shown that $x_j = d/dt \int_0^t F(t-y)h_j(y)dy$, $(j = 1, 2, \ldots n)$, so that the solution of equations (1) as modified depends entirely on equations (2). The latter formulate the problem actually dealt with by Heaviside. His mode of attack was to write p^n for d^n/dt^n, so making (2) formally algebraic and yielding a *purely symbolic* solution $h_j = 1/H_j(p)$. The problem remains to find the meaning of this equation and find $h = h(t)$ as a function of t. This Heaviside did by pure induction, inferring, from known solutions of specific problems, general rules for expanding and interpreting the operation formula. The body of rules so developed the author calls the Heaviside Operational Calculus, to which his contribution is the following proposition and its corollary: The equations (2), subject to the prescribed boundary conditions may be written as $h_j = 0$, for $t < 0$ and $j = 1 \ldots n$, $1/\{pH_j(p)\} = \int_0^\infty e^{-pt}h_j(t)dt$, for $t \geq 0$. The integral equation is an identity for all positive real values of p and consequently determines $h_j(t)$ uniquely. *Corollary.*—The equation $h = 1/H(p)$ is merely a shorthand or symbolic equivalent of the integral equation $1/\{pH(p)\} = \int_0^\infty e^{-pt}h(t)dt$. The significance of the operational equation and the rules of the Heaviside calculus are therefore deducible from the latter equation, so that the problem is reduced to the purely mathematical problem of solving the integral equation. The operational method is applicable also when the number of variables is infinite and to such partial differential equations as the *telegraph equation*. The foregoing theorem applies also to all such physical problems where an operational formula $h = 1/H(p)$ is derivable. G. W. DE T.

1059. *Dimensional Analysis.* **N. Campbell.** (Phil. Mag. 47. pp. 481–494, March, 1924.)—The author critically re-examines the physical assumptions underlying dimensional analysis, and offers suggestions of a method of employing dimensional arguments which is less liable to error than those generally employed. His final conclusion is that dimensional analysis is useful and valid only when the assumptions concerning the magnitudes involved and their dimensions are based on the inspection of equations expressing fully the numerical laws or theories by which the process under discussion is determined. If they are so based, then all the formalities which various writers have elaborated are useless; no fixed dimensions or fixed fundamental magnitudes need be introduced; all that is required is a sound appreciation of the meaning of similarity and a knowledge of the rule, which is one of its obvious consequences, that all terms in a numerical law have the same dimensions. He considers it to be probable that, in all useful and valid cases, the fundamental numerical laws or theories are expressible in differential equations; and that the only significant result of dimensional analysis is the generalisation, for cases in which those equations are mathematically intractable, of a result which can be established by full mathematical reasoning in simpler cases. It is possible that there are exceptions to this statement, though none have been discovered. In any case the errors that arise when dimensional arguments are based on anything but differential equations are so facile and so plausible that any argument not so based should be accepted only after the most careful scrutiny in the light, not of an elaborate statement of the formal logical process employed, but of the physical significance of the assumptions made. Incidentally some arguments by Jeans and by Einstein, which seem to have been accepted as valid, are discussed. It is concluded that the former, while formally valid, are not significant and do not really involve the concept of dimensions; and that the latter are completely fallacious. G. W. de T.

1060. *The Aerodynamic Study of Birds' Wings, and of Flexible Aeroplane Wings.* **E. Huguenard, A. Magnan,** and **A. Planiol.** (Comptes Rendus, 178. pp. 193–196, Jan. 7, 1924.)—In dealing with wings which are flexible, and so bend under stress, the lift and drag coefficients are functions of the air-speed as well as of the angle of attack. Owing to the almost insuperable difficulty of constructing a model to behave in a fashion dynamically similar to the full-size machine, model experiments are not useful—and in consequence, natural winds must be used on the full scale. An apparatus for doing this, using continuously recording instruments to determine the wind speed and direction, and the lift and drag, is described, and some records given. W. G. B.

1061. *The Lanchester-Prandtl Theory of Aeroplane Lift and Drag.* (Engineering, 117. pp. 1–3, Jan. 4; 35–37, Jan. 11; 100–102, Jan. 25; 169–171, Feb. 8, and pp. 258–260, Feb. 29, 1924.)—An account of this theory, elementary in that it presupposes no acquaintance with it on the part of the reader, but at the same time quite comprehensive.

The resolution of the paradox that, whereas the air, except in the immediate neighbourhood of the plane, moves in stream-lines, and behaves practically as a perfect fluid, which exerts no resultant force on an immersed solid, yet aeroplanes are able to fly, is due to an idea originally due to Lanchester, that circulation round the wing would give rise to a supporting force, and that such circulation is in fact produced by the adhesion of the air to the wing surface; the wing surface is a "vortex sheet." The case of combined flow past and circulation round a cylinder is treated in detail, as the process of "conformal transformation" can convert the cylinder into a wing section and the resultant force can be calculated by use of this transformation. The effects of finite aspect ratio are next considered and as the pressure decreases from the centre out, we get another vortex system, which explains a large portion of the drag. Deductions as to the best form of wing plan follow, that of an ellipse, or two semi-ellipses being found. Such considerations have allowed Betz and Munk to combine the data as to lift and drag for many wings into a single diagram, with remarkably good agreement. A discussion of interference between two or more wings, and of propellers, aided by a fruitful electrical analogy, concludes the series. W. G. B.

1062. *Influence of the Earth's Rotation on a Top.* **J. L. Synge.** (Phil. Mag. 47. pp. 525–529, March, 1924.)—Foucault's theory of the rotation of the plane of swing of a pendulum due to the rotation of the earth, led him to predict analogous effects on a spinning top. According to his theory, the axis of the top should lie in the meridian, but be inclined to the vertical, south or north according as the rotation is right or left handed. Also, if a top be spun on a horizontal plane surface, it should tend to travel from west to east. Foucault claimed to have observed both effects, but the author shows rigorously that the effect is in the opposite direction in each case to that which Foucault expected. A. Wh.

1063. *The Thermal Conductivity and Compressibility of Several Rocks under High Pressures.* **P. W. Bridgman.** (Am. J. Sci. 7. pp. 81–102, Feb., 1924.)—The material whose conductivity was to be measured was worked to the form of a cylindrical shell which was slipped between an outer and an inner cylinder of copper, each of which it fitted accurately. An insulated wire stretched along the axis of the inner copper cylinder carried an electric current, so that the axis was a source of heat. The entire apparatus was submerged in a bath of petroleum, ether, or kerosene, and the pressure was applied to this liquid. A correction had to be applied for the thermal resistance of the film of liquid between the copper cylinders and the sample under test. The magnitude of this correction varied with the pressure. The thermal conductivity of pipestone, talc, Solenhofen limestone, basalt, pyrex glass and rock salt was measured up to 12,000 kg./cm.^{2} at 30°, and in most cases at 75° also. The conductivity increases with rising pressure by an amount which may vary from 0·1 % per 1000 kg. at 30° for Solenhofen limestone to 3·6 % for rock salt. Probably for the ordinary rock of the earth's crust the effect is not over 0·5 % at ordinary temperatures. The absolute conductivity and its pressure coefficient may either increase or decrease with rising temperature.

Compressibility.—A simple hydrostatic pressure applied to substances of the character of those measured does not in general produce a uniform change of volume, but the effects are complicated. The relation between pressure and deformation may be affected by hysteresis in a direction the reverse of normal; this was found to be the case in pipestone, Solenhofen limestone, and basalt in amounts varying from a few per cent. to 18 per cent. of the whole deformation. Talc and pipestone show large differences of linear compressibility in different directions; this effect was not investigated for the other materials. Pyrex glass has an abnormal increase of compressibility at high pressures.

Geological Consequences.—As far as the results on thermal conductivity go, only rough conclusions can be drawn, but it would seem that in view of the possible variations found with pressure and temperature one should be prepared in geological speculations to consider that thermal conductivity at a depth of several hundred miles away may be several fold greater than the value now accepted. That the compressibility is different in different directions suggests that deep in the earth's crust where there are large differential stresses, with the probability of much greater variations with direction than those found in these experiments, it may be very far from the truth to represent the elastic behaviour as that of a single homogeneous isotropic solid with two elastic constants. E. G.

1064. *The Crystalline Structure of Hydrogen Chloride.* **F. Simon** and **Clara v. Simson.** (Zeits. f. Physik, 21. 3. pp. 168–177, 1924.)—Since HCl only solidifies at very low temperatures, and even if large crystals could be obtained it would be difficult to manipulate them, the Debye-Scherrer method was employed. In order to obtain a narrow cylindrical surface covered with the crystals, hydrogen was passed through a spiral tube cooled in liquid air, and into a straight, thin, metal tube, which passed down the axis of the X-ray camera, which was joined to the X-ray bulb by a vacuum tight joint. HCl was passed into the camera, and condensed and solidified on the outside of the cooled tube, forming a hollow cylinder of minute crystals along the axis of the camera. The metal tube beneath the crystals produced hardly any lines on the radiographic plate, on account of the absorption of the layer of crystals surrounding it. The solid modification of HCl obtained in this way proved to crystallise in a cubical, surface-centred lattice, with a lattice constant $a = 5 \cdot 54$ Å.; below 98° abs. the crystal form alters, and the lattice becomes more complicated, so that, although 28 lines have been photographed, the structure has not been determined. To obtain the solid in this form it was necessary to pass liquid oxygen through the capillary tube. Reasons are given for thinking that the lattice is molecular and not ionic; and attention is called to the theoretical importance of the change from lower to higher symmetry with increased temperature. It is concluded that this higher symmetry does not originate in the stationary HCl molecule, but is the result of the thermal movements, probably of rotation about one or two axes; this shows that the assumption, made by Born, of a cubical lattice with stationary molecules cannot be correct. H. N. A.

1065. *X-Ray Analysis of Coal.* **C. N. Kemp.** (Colliery Guardian, 127. pp. 539–541, Feb. 29, 1924. Paper read before the North of England Inst. Mining and Mech. Eng., Newcastle, Feb., 1924.)—The application of X-ray methods to the analysis of coal was discussed, and earlier work reviewed. The preliminary experiments indicate the value of this method of analysis for examination of coal, and it was found that the increase in percentage of ash increased the absorption. F. J. B.

1066. *The Crystalline Structure of Organic Substances.* (Engineering, 117. pp. 211–212, Feb. 15; 244–245, Feb. 22; 274–275, Feb. 29, and pp. 310–311, March 7, 1924. An account of lectures delivered by **W. H. Bragg** before the Royal Inst.)—The 230 possible arrays of atoms in space, discovered mathematically some thirty years ago, lead to a smaller number of possible classes, the crystals of which look alike, and the structure of which cannot be differentiated except by means of X-rays. At one point X-ray methods fail; some molecules have polar properties, and form crystals with different properties on opposite faces, this can generally be settled in other ways. A model was employed consisting of three horizontal sheets of glass, equally spaced one above another, on which wooden ellipses, divided into four parts, differently coloured top and bottom, were placed to represent the structural units, and when necessary "polar" molecules; with this representations of different molecular arrangements could be displayed, and in two diagrams 22 different "patterns" of cubical crystal were shown. Monoclinic crystals were also explained with the help of the model. Since in organic crystals the molecule seems to keep its shape and character when built up into a crystal, certain points can be more easily established with these substances than with less complex bodies; the way in which the naphthalene molecule has been fitted into the crystalline structure of the substance, as revealed by the X-rays, is given as an example, together with the numerical coincidence between measurement and theory when the cells of naphthalene and anthracene are compared. The lecturer drew attention to the emptiness of the crystal structure in these cases, suggesting a piece of lace rather than a continuous solid. The behaviour of long chains of carbon atoms, each with two hydrogen atoms attached, as in the fatty acids, was explained, and it was shown that they were joined together so that the bonds made angles of about 106° 46′ with one another, as in the diamond. In Iceland spar, however, each carbon atom is at the centre of an equilateral triangle, with O atoms at the corners; here the O atoms have taken all its valency electrons from the carbon, which is positively charged, the O atoms take two additional electrons from the Ca atom, so that each O atom has eight electrons in its outer ring. The most recent experiments with good crystals of graphite show conclusively that the carbon rings in the sheets of graphite are not flat, but puckered as the lecturer had anticipated. H. N. A.

1067. *Structure of Magnesium Stannide.* **L. Pauling.** (Am. Chem. Soc., J. 45. pp. 2777–2780, Dec., 1923.)—The intermetallic compound Mg_2Sn is investigated by X-ray spectrum and Laue photographs. The structure is shown to be that known as the calcium fluoride arrangement. There are eight magnesium atoms round each tin atom at the corners of a cube, and four tin atoms round each magnesium at the corners of a tetrahedron. The constants are $d_{100} = 6 \cdot 78 \pm 0 \cdot 02$ Å.U., and for closest approach $2 \cdot 94 \pm 0 \cdot 01$ Å.U. The structure of sodium cadmide $NaCd_2$ is too complicated to unravel by this treatment. A. Wh.

1068. *The Structure of Aragonite.* **W. L. Bragg.** (Roy. Soc., Proc. 105. pp. 16–39, Jan. 1, 1924.)—Calcite forms rhombohedral crystals, the structure of which has been analysed by several workers, while aragonite crystals have orthorhombic symmetry, and are generally assigned to the holosymmetric class; this agrees with the author's results, though the symmetry may be actually lower owing to some very small distortion, which is not revealed by X-ray examination. The crystals are pseudo-hexagonal; simple crystals are rare, as twinning about the plane (110) is nearly always present. Repeated twinning produces interpenetrating groups almost indistinguishable from simple hexagonal crystals. A number of diagrams illustrate the steps by which the author arrives at a structure which accounts for the observed relations between the spectral intensities, and he calls attention to the similarities and differences between this structure and that of calcite; the distance in one direction between successive layers of calcium atoms is $2 \cdot 86$ Å.(d_{111})in calcite and $2 \cdot 86$ Å.(d_{001})

in aragonite; in a plane perpendicular to this direction the distance between the calcium atoms is 4·96 Å., while in aragonite it is slightly different in different directions, being 4·94 Å. parallel to the "*a*" axis and 4·66 Å. in two other directions. It appears that in calcite each oxygen atom lies between two calcium atoms, in the position shown in Fig. 1, while in aragonite the whole CO_3 group has turned round through 30°, so that each oxygen lies between three calcium atoms as in Fig. 2. An interesting section perpendicular to the "*c*" axis of aragonite showing the relative positions of the atoms explains twinning on the plane (110.) The aragonite structure is based on the simple orthorhombic lattice (Γ_0); the cell, whose sides are 4·94 Å., 7·94 Å., and 5·72 Å., contains four molecules of $CaCo_3$; it is shown by a process of elimination that the elements of symmetry form the space group Q^{16}, using Hilton's notation; the calcium atoms are arranged in a distorted hexagonal close-packed system; the intensity appears to be proportional to the amplitude factor, and not to its square as theory would suggest; this is in accordance with W. H. Bragg's result for calcite. H. N. A.

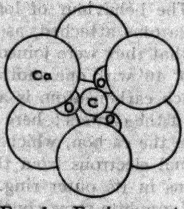


FIG. 1.—Environment in calcite.

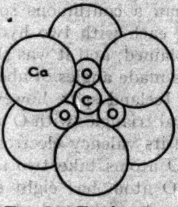


FIG. 2.—Environment in aragonite.

1069. *Perturbations of the Orbit of the Valency-Electron in the Generalised Hydrogen-unlike Atom (A).* **K. Basu.** (Calcutta Math. Soc., Bull. 14. pp. 107–140, Sept., 1923.)—A mathematical investigation, on the lines of the method adopted by Goldsbrough in connection with the theory of lunar perturbations. A. B. C. L.

1070. *Electric Moment and Electrical Structure.* **C. P. Smyth.** (Phil. Mag. 47. pp. 530–544, March, 1924.)—An amplification of conclusions reached in an earlier paper [Abstract 1748 (1923)]. The moments of many compounds are discussed and the effect of the displacement of electrons by the nuclei of adjacent atoms is considered. Fair agreement is shown in many cases with theory. While the inverse square law cannot be exact for these distances, errors introduced by using it are small. The results also support the Bohr-Thomson-Bury theory that the outer shell of an atom cannot contain more than eight electrons. A. Wh.

1071. *The Motion of Electrons in Neon.* **V. A. Bailey.** (Phil. Mag. 47. pp. 379–384, Feb., 1924.)—The mean free path and the average energy loss during a collision are investigated for various electron velocities. The method has been previously described [Abstract 135 (1924)] and results alone are tabulated, a correction being made for 1 % helium in the neon used. For velocities less than 10^8, the free paths are in the same order as the atomic numbers, but at no point agree with the values calculated from viscosity. The collisions appear to resemble those between perfectly elastic spheres, the order of magnitude being correct, but there are reasons to believe that this agreement is merely superficial and does not represent the facts. A. Wh.

1072. *Bohr's Model of the Atom.* **E. E. Free.** (Indust. and Engin. Chem. 16. pp. 192–194, Feb., 1924.)—A review.

1073. *The Supersaturated State in Highly Rarefied Vapours.* **L. Wertenstein.** (J. de Physique et le Radium, 4. pp. 281–292, Aug., 1923.)—The author points out that condensation in the case of supersaturated vapours at pressures of the order of 0·001 mm. mercury does not take place on dust particles or ions in the mass of the gas, but only on the walls of the enclosure. Following Knudsen [Abstract 1357 (1916)], he considers a quantity ϵ, expressing the probability of a molecule adhering to the wall at any given impact. This function is found to be discontinuous, giving a region of slow, and also one of rapid, condensation.

The experimental arrangement consisted of a light mica disc free to swing about its centre, suspended in an apparatus, evacuated except for the vapour given off by a drop of mercury placed in the lower part of the apparatus. The mercury container could be maintained at a different temperature from the vessel containing the mica disc, and the pressure of the mercury-vapour in the latter was deduced from the logarithmic decrement of the oscillations of the disc. Experiments were made with mercury at various temperatures above that of the measuring apparatus, and the changes in rate of condensation observed. Other experiments are described, in which the apparatus could be put in communication with a tube containing glass wool, and the absorption of the mercury by this substance followed by means of the fall of pressure. From the results, by means of a few simple assumptions, the mean life of an atom on the surface of the glass, and their average distance apart (which is a considerable number of diameters) can be calculated approximately. E. G.

1074. *X-Rays and the Atom.* **O. Lodge.** (Brit. J. of Radiology, 20. pp. 6–19, Jan., 1924.) *Evidence for the Nuclear Atom.* (Nature, 113. pp. 15–17, Jan. 5, 1924. Extract.)—In the course of a general review of the subject the lecturer made the following rather tentative suggestions: The proton is always in a state of circulation at a speed comparable with the velocity of light, this would account for its mass; the normal ether contains a constitutional rotation comparable to the velocity of light; on this, when a pair of electric units are generated, two equal and opposite rotations are superposed, one in opposition to the original rotation, the other in the same direction, giving a velocity conceivably sufficient to account for the mass of the proton. In any case there may be etherial circulation round the nucleus, very intense near to the nucleus and decreasing with distance, with unexplained discontinuities of finite change of speed, or change of law of force in strata where the speed obeys the ordinary astronomical law; these might be called gravitational or electrical levels, and if an electron entering the whirl was at any of these levels it could be carried forward by the fluid at that place, in a state which satisfied its own requirements, and the revolution would not be one involving acceleration and consequent radiation, the electron being at rest with reference to the part of the fluid round it. It would be necessary to assume that a particle slightly perturbed from the orbit would return to it after some oscillations, and that instability would only set in if the perturbations exceeded some definite magnitude. If the restoring force is proportional to the fourth power of the speed of the whirl, on the other assumptions made, the frequency of oscillation is proportional to the energy to be radiated, and the radiation of energy will be as the square of the restoring force, that is as the square of the effective radiation, in accordance with Larmor's law. A very simple account of the Bohr orbits, explaining the relation between the different circular and elliptical orbits in the atomic levels K, L, M, etc., is given in the portion of the address published in "Nature" and includes a useful explanatory diagram. H. N. A.

1075. *Application of the Quantum Theory to Atomic Structure.* **N. Bohr.** (Cambridge Phil. Soc., Proc. Supplement, [42 pp.] 1924.)—Translation of paper dealt with in Abstract 1315 (1923.)

1076. *Quantum Statistics of Energy Fluctuations.* **M. Planck.** (Preuss. Akad. Wiss. Berlin, Ber. 33. pp. 355–358, 1923.)—The energy fluctuations in a field of stationary monochromatic radiation was first considered statistically by A. Einstein [Abstract 909 (1909)], using a method depending on the relation between entropy and probability. In common with all thermodynamic methods, it is applicable only to systems having a very large number of degrees of freedom. Subsequently, v. Laue [Abstract 1289 (1915)] discussed the same question for a system having only one degree of freedom by a direct probability method, but for systems of more than one he confined himself to determining the mean square values of the fluctuations. In the present paper the author fills this gap, by obtaining a general solution of any number of degrees of freedom, without recourse to any thermodynamic considerations. The result obtained agrees, as it should, with Einstein's in the case of systems with many degrees of freedom and with v. Laue's in the case of one degree of freedom. G. W. DE T.

1077. *Does the Field Theory Offer Possibilities for the Solution of the Quantum Problem?* **A. Einstein.** (Preuss. Akad. Wiss. Berlin, Ber. 33. pp. 359–364, 1923.)—It is characteristic of all field theories hitherto proposed that the equations allow the free choice of initial conditions. This is contrary to the physical facts: the initial state of an electron moving round a nucleus cannot be chosen arbitrarily but must satisfy the quantum conditions. To take account of this law of nature, the system of partial differential equations which determine the field variables must be "super-determinate": there must be more of them than there are field variables. The attempt must therefore be made to find a set of covariant equations between the g_{ik} and the ϕ_{ik}, containing the gravitational and electrical equations:

$$R_{ik} = -\kappa T_{ik} \equiv -\kappa(-\phi_{i\alpha}\phi_k^{\alpha} + \tfrac{1}{4}g_{ik}\phi_{\alpha\beta}\phi^{\alpha\beta})$$

and others besides. They must admit the statical, spherically symmetrical solution which characterises the positive and negative electrons. A tensor $\Psi_{ik,lm}$ is first written down containing g_{ik}'s and ϕ_{ik}'s (but not their derivatives), having the same symmetry properties as $R_{ik,lm}$, and such that $g^{il}\Psi_{ik,lm} \equiv - T_{km}$. The equations $R_{ik,lm} = \Psi_{ik,lm}$ . . (1) are too stringent to be adopted, for, since the $\Psi_{ik,lm}$ all vanish with the ϕ_{ik}, the metric would be necessarily Euclidean in the absence of electricity. The identity $R_{ik,lm;n} + R_{ik,mn;l} + R_{ik,nl;m} \equiv 0$ has, however, been proved by Bianchi (; a denoting covariant derivation), so that the equations $\Psi_{ik,lm;n} + \Psi_{ik,mn;l} + \Psi_{ik,nl;m} = 0$ are contained in (1). These are satisfied by the statical electron solution, and it is suggested that, together with the original equations $R_{ik} = -\kappa T_{ik}$, they form the required " super-determinate " set.

Emphasis is laid rather on the idea of " super-determinacy " than on the particular set of equations propounded. M. H. A. N.

1078. *The Dynamics of the Impact between a Light Quantum and an Electron.* **L. S. Ornstein** and **H. C. Burger.** (Zeits. f. Physik, 20. 6. pp. 351–357, 1924.)—It is assumed at the outset that it is possible to determine completely the impact electron-light quantum, *i.e.* if ν, v_x, v_y, v_z, α, β, γ are given then ν', v'_x, v'_y, v'_z, α', β', γ' should be calculable. For this purpose a model of a light quantum is devised and mathematically described leading to the results desired. Reference is made in an appendix to a paper by Pauli dealing with the same problem, obtaining a like result, and deriving the Wien radiation law without any special hypothesis. The authors, however, point out a difference between their assumption for the probability of a collision between a quantum and an electron and the expression found by Pauli. From the Pauli equations it follows that the probability for an encounter is inversely proportional to the energy of the electron, which appears difficult to understand on physical grounds. The explanation of this discrepancy lies in the assertion of Pauli that a Lorentz transformation can account for the effect between quantum and electron before and after collision, this being regarded as invalid by the present authors. H. H. Ho.

1079. *The True Relation of Einstein's to Newton's Equations of Motion.* **L. Silberstein.** (Nature, 112. pp. 788–789, Dec. 1, 1923.)—It is shown that the Newtonian equations of motion for a particle under gravitation: $d^2\xi_i/dt^2 = \partial\Omega/\partial\xi_i (i = 1, 2, 3)$: commonly exhibited as an approximate form of the general equations of the geodesic when only first order small quantities are retained, can also be interpreted as the exact equations of the path of the particle in a certain " unaccelerated " system of coordinates, momentarily at rest relative to it. M. H. A. N.

1080. *Whitehead's Re-formulation of the Data of Physical Science.* **G. W. de Tunzelman.** (World Power, 1. pp. 171–175, March, 1924.)—A statement of the position, with particular reference to the difference between the methods of Whitehead and Einstein. W. R. C.

1081. *A Non-Homogeneous Radiation Field.* **W. Wessel.** (Zeits. f. Physik, 21. 1. pp. 63–67, 1924.)—It is known that in a medium filled with electromagnetic radiation and in a state of radiant equilibrium, no dispersion occurs since every ray gains from others what it loses. Similarly for the absorption and emission in cases of non-homogeneous radiation, an exponential law for absorption is transformed by emission into the usual quadratic form. It is now asserted that in an homogenous and unlimited absorbing and emitting medium, the intensity of the radiation proceeding from a point source of light decreases in the stationary radiation equilibrium according to a quadratic law with the distance, and approximation to the asymptotic law depends on the speed and strength of the absorption. The proof on energetic grounds of the above physical hypothesis depends on a solution by Hilbert of the integral equation for the Kirchhoff hypothesis. Jaffé's form for the latter is used [see Abstract 937 (1923)]. The extension is then made to the non-homogeneous radiation field in which the radiation intensity is a function of the direction at every point. The paper is entirely mathematical. H. H. Ho.

1082. *Coordination of Movements and the Notion of Time.* **J. le Roux.** (Comptes Rendus, 178. pp. 316–319, Jan. 14, 1924.)—General considerations as to the independent coordinating variable analytically necessary in a moving system (having regard to canonical forms and to the principle of least action) connect the ordinary idea of time with the fact of gravitation, apart from Einstein's views, which are not helpful in this respect. A. D.

1083. *The Einsteinian Deviation of Luminous Rays by the Sun.* **E. Esclangon.** (Comptes Rendus, 178. pp. 196–199, Jan. 7, 1924.)—The author investigates the measures by Campbell and Trumpler of the eclipse plates of 1922, and finds that they do not conform: (*a*) to the analytical law $d = a/r = 1''\cdot 24/r$, but that a hyperbolic curve more nearly fits the data in the interval ($r = 32'$ to $r = 3^\circ\cdot 30'$) containing the observations; (*b*) to the Einsteinian constant, $1''\cdot 74$. On the contrary the value $2''\cdot 05$ is adopted, and the value $2''\cdot 50$ would fit the observations as nearly. Therefore he concludes that the observations neither confirm nor disprove Einstein's law of deviation, but only indicate that deviations do exist near the sun, without indicating their law or amount; and that observations at future eclipses are needed to obtain sure results. A. S. D. M.

1084. *Gravitation.* **A. S. Eddington.** (Roy. Astron. Soc. Canada, J. 17. pp. 387–398, Nov.–Dec., 1923.)—The explanation of gravitation is divided into four stages. (1) Gravitation requires explanation so far as it is a law. Explanation is required of the constraint of phenomena, which is manifested in its most varied form in the neighbourhood of heavy masses. (2) The Einstein equations describe the order in the universe, and they are satisfied by empty space. (3) The interpretation of these equations is that space-time has an homogeneity and isotropy as regards a certain characteristic—namely, curvature defined in a certain way. (4) The mystery of the homogeneity and isotropy disappear when we realise that it is not intrinsic in the external world, but in the measurements we make of the world. W. A. R.

1085. *Spontaneous Loss of Energy by a Spinning Rod.* **A. S. Eddington.** (Phil. Mag. 46. pp. 1112–1117, Dec., 1923.)—The question whether the gravitational waves set up by a spinning rod gradually dissipate the energy and bring the rod to rest has been investigated by Einstein [Abstract 606 (1918)] and the author. It was found that energy is in fact lost at the rate of $32/5kI^2\omega^6$ per second, where k is a universal constant having, in c.g.s. units, the value $2\cdot 7 \times 10^{-60}$.

In the present paper this result is obtained by a new and shorter method. Since gravitation is not propagated instantaneously we may expect the lag to give rise to tangential components of the force opposing the motion of the system. The mutual attraction of the particles is not in the line of the rod, and the result is a couple which slowly destroys the rotation. The effect is of the third order in v^2/c^2, so that expansions must be continued to this extent. The result $32/5k\mathrm{I}^2\omega^6$ is obtained, in agreement with previous work, on the assumption that $(\mathrm{M}/a)^3v^2$ and $(\mathrm{M}/a)^4v^2$ are small compared with $(\mathrm{M}/a)^2v^6$ (where v is the linear velocity. The velocity of light is 1). Examples can be made for which this is true, but in the case of double stars v^2 is comparable with M/a and the method therefore fails. M. H. A. N.

METEOROLOGY AND GEO-PHYSICS.

1086. *Peruvian Meteorology.* **S. I. Bailey.** (Astron. Obs. Harvard Coll. Annals, 86. 3. pp. 123–194, 1923.)—Observations made at the auxiliary stations 1896–1900.

1087. *The Development of Meteorology as Illustrative of the Rôle of Mathematics in the Progress of Science.* **E. W. Woolard.** (Monthly Weather Rev. 51. pp. 645–649, Dec., 1923. Paper read before the Math. Assoc. of America, Dec., 1923.) A. W. L.

1088. *A Limit-Gauge for Rainfall.* **F. J. W. Whipple.** (Roy. Meteorolog. Soc., J. 50. pp. 23–24; Disc., 24–25, Jan., 1924.)—Insurance against rainfall is often based upon the occurrence of a fall of at least 0·1 in., the limits of accuracy allowed being 0·005 in. A small glass measure has been constructed to fit into a 5-inch rain-gauge, with its stem graduated at 0·095 and 0·100 in.; this instrument is of value when an accurate determination of whether these limits have been passed is required. A. W. L.

1089. *The Fall of the Barometer during the Passage of Cyclones and Typhoons.* **F. E. Fournier.** (Comptes Rendus, 178. pp. 28–30, Jan. 2, 1924.)—If P is the pressure around a cyclone or typhoon and p that at a point in the path of the system, the curve obtained by plotting the fall of the barometer $(\mathrm{P}-p)$ against time is symmetrical, showing ascent to a maximum followed by descent. The ascending curve is at first convex, but after reaching a maximum slope θ_1, where the pressure is p_1, it becomes concave. The curvature of the convex arc is a maximum at a point x where $\theta_x = \frac{1}{2}\theta_1$. If ϕ is the angle between the radius of the storm through the point considered and the diameter along which the storm is travelling, the maximum value of θ is an inverse function of ϕ. The convex arcs may be expressed by the equation

$$\theta = (90 - \phi)\left[\frac{\mathrm{P}-p}{\mathrm{P}-p_1}\right]^{\frac{\log 2}{\log(\mathrm{P}-p_1)-\log(\mathrm{P}-p_x)}}$$

or $\phi = 90 - 2\theta_x$ when $\mathrm{P}-p = \mathrm{P}-p_x$. Hence ϕ may be readily obtained from observations at a single station. A. W. L.

1090. *The Dynamics of Cyclones and Anticyclones regarded as Atmospheric Vortices.* **D. Brunt.** (Roy. Soc., Proc. 105. pp. 70–80, Jan. 1, 1924.)—The author first writes down and solves the gradient wind equation algebraically as a quadratic. Reasons based on considerations of continuity, energy supply, and stability are adduced for rejecting one solution. The form of the solution of the equation for an anticyclone shows that there is an upper limit to the angular velocity of any portion of an anticyclone about the instantaneous centre of curvature of its path. This upper limit is $\omega \sin \phi$, so that the anticyclone viewed from outside the earth is being carried round counter-clockwise by the rotation of the plane of the horizon faster than it rotates in that plane. Hence an observer outside the earth would see an anticyclone as a counter-clockwise circulation in space. The question naturally arises, would he also regard it as a centre of low pressure? It is found on examination that an anticyclone will always appear to be a centre of high pressure. The rotation of the earth's atmosphere as a solid about the axis of the earth forms a circumpolar whirl, in which the field of pressure is everywhere uniform. It is shown that a cyclone and an anticyclone may be regarded as a local enhancing or diminution of the vorticity of the circumpolar whirl. **Author.**

1091. *The Cause of Cyclones.* **H. Jeffreys.** (Roy. Meteorolog. Soc., J. 50. pp. 61–64; Disc., 64–67, Jan., 1924.)—The principal theories which have been put forward to explain the origin of cyclones are discussed. A large stationary cyclone, such as that over Central Asia in summer, might be due to local heating, and phenomena on a comparatively small scale, such as thunderstorms, may be produced by atmospheric instability. No satisfactory explanation of the cyclones of middle latitudes has been obtained; it is suggested that these may be due to the instability set up by the mixing of the two currents at the polar front. A. W. L.

1092. *Attempts to Measure Air Temperature by Shooting Spheres Upward.* **L. F. Richardson.** (Roy. Meteorolog. Soc., J. 50. pp. 19–21; Disc., 21–22, Jan., 1924.)—A method of measuring wind velocity by shooting polished steel spheres upward from a gun has already been developed and the theory published [see Abstract 2109 (1923)]. It appears that the time of absence of the sphere may also be made to give a measure of a mean temperature of the air up to the greatest height reached by the shot. But, before this can be done, there are a number of small effects, which mask that sought, and which must be eliminated. An "air-gun" was found better than one using an explosive charge. Then there is the temperature of the gun, its tilt (the inclination given to the gun so that the wind brings the shot back practically to the starting-point), and barometric pressure. These effects are dealt with in the present communication, and a table of constants is given which will be required by anyone continuing the experiments. It was found that the upper-air temperature could be measured from the mean of six shots with a standard error of 1° C. at sunrise in calms or light winds. It is just then that an "inversion" often occurs, so that the "screen" reading at the surface is little guide to the temperature aloft. An important application would accordingly be that of obtaining a more suitable temperature for use in reducing barometer readings to sea-level on such occasions, as suggested by **J. S. Dines** in the discussion. The height reached by the shot in the experiments described was of the order of

120 m. The accuracy on hot afternoons was less than that stated above for calm mornings. M. A. G.

1093. *Relation of the Circulation in the Upper Air to a Circumpolar Vortex.* **A. W. Lee.** (Roy. Meteorolog. Soc., J. 50. pp. 69–74, Jan., 1924.)—Maps of the average pressure distribution at different levels, deduced from that at sea-level with certain assumptions as to the mean lapse rate of temperature, show that, on the assumption of "geostrophic balance," the "general circulation" of the upper air is of the nature of a huge circumpolar vortex. The present investigation shows that the extra-tropical circulation at any level approximates to that of a V/*r* vortex, or solid rotation, although it has often been supposed to be of the V*r* type. It appears "that each layer is an aerosphere which rotates around the polar axis as a solid, but on ascent there is relative motion between consecutive aerospheres." The circulation being from west to east relative to the earth, each aerosphere rotates round the earth's axis somewhat faster than the earth does. In July, the excess angular velocity is 2·6 per cent. at 4 km., 3 per cent. at 6 km., and 4·3 per cent. at 8 km. in the northern hemisphere. Other points dealt with are the small departures from true solid rotation, and deductions as to the travel of air from equator to pole in the upper regions. M. A. G.

1094. *Resilience, Cross-Currents, and Convection.* **N. Shaw.** (Roy. Meteorolog. Soc., J. 50. pp. 1–18, Jan., 1924.)—A discourse prepared as an introduction to a discussion of the basis of meteorological theory held at the meeting of the Royal Meteorological Society, October 17, 1923. The first section discusses the stratification of the atmosphere by virtue of the normal increase of potential temperature with height, leading to the possibility of regarding the whole mass as being separable into a number of quasi-independent layers or "aerospheres"; an important generalisation in connection with the consideration of cloud layers and the development of revolving fluid. The second section deals with the disturbance of adjacent aerospheres by eddy-motion, arising where there is relative motion between them. The "spiral" law of approach from the surface wind to that at a height free from the effects of the eddy-motion generated at the surface has been worked out by a number of authors [see *e.g.* Abstracts 518 and 818 (1920)]. An extension is here suggested to the case of the transition from one wind current to another in the middle atmosphere, when there is a discontinuous or rapid variation of horizontal pressure gradient with height. In such a case the vector representing the wind at any level traces out a "double spiral" (instead of a single one as in the case cited above) in passing from the lower to the upper undisturbed current through the region affected by the turbulence.

The third section deals with the disturbance of the aerospheres by "convection," and treats of the various modes of vertical motion in the atmosphere, and the evidence there is for their occurrence. M. A. G.

1095. *Distribution of Air Density over the Globe.* **S. N. Sen.** (Roy. Meteorolog. Soc., J. 50. pp. 29–49; Disc., 49–51, Jan., 1924.)—The air density at M.S.L. in January and July has been found at the centre of each ten-degree square from 10° N. to 80° N. and from 10° S. to 70° S.

From these values the isopycnics, or lines of equal density, have been charted; these lines are approximately parallel to the latitude, but show centres of high density over N. America and N. Siberia. The distribution in the upper air has been found for each hemisphere in summer, at intervals of 1 km., up to 10 km., from the surface conditions assuming mean values for the lapse-rate of temperature. The distribution up to 7 km. is of the same type as that at the surface, but at 9 and 10 km. it is reversed, and the air over the equator is denser than that over the pole; at 8 km. the density is approximately constant all over the globe. The equisubstantial surfaces have been found from the mean density for each ten degrees of latitude at these levels. The slope of the equisubstantial surfaces is from the pole to the equator below 8 km., and from the equator to the pole above 8 km.; at 8 km. the equisubstantial surface is practically horizontal.

As the density changes up to 7 km. are chiefly controlled by the temperature, the name "thermosphere" has been suggested for this layer; the region above 8 km., where the pressure variations become predominant, has been termed the "barosphere." The intermediate layer where the density is constant, has been termed the "thermopause." If the insolation is increased the density in the thermosphere is decreased and that in the barosphere is increased. A. W. L.

1096. *Earth Density.* **H. S. Washington.** (Washington Acad. Sci., J. 13. pp. 453–456, Dec. 19, 1923.)—A re-examination of the densities of the rocks of Mauna Loa leads to a revision of Preston's calculation of the mean earth density by a survey of that mountain. Preston used vesicular specimens under the impression that the bulk of the rocks were of that type, but a petrological survey indicates that lower down below the surface there is very little scoriaceous or vesicular material. The revised mean for both localities gives 5·560 for the mean earth density, which is closer than Preston's to the accepted value. W. A. R.

1097. *Density Distribution in the Earth.* **E. D. Williamson** and **L. H. Adams.** (Washington Acad. Sci., J. 13. pp. 413–428, Nov. 19, 1923.)—The density distribution proposed takes into account changes due to compression alone. Earthquake data furnish a quantitative estimate of that part of the density change due to compression alone in various materials. The continuity of the velocity curves is now reconciled with velocity differences in metallic iron and basic silicate. The distribution gives four zones. Two are sensibly constant in composition but not in density—the central core of metallic iron and the periodotitic shell immediately below the surface layer. The surface shell and the pallasite fringe (the intermediate zone of mixed silicate and metal, surrounding the core) are of variable composition. W. A. R.

1098. *Intensity and Direction Measurements of Penetrating Radiations.* **W. Kolhörster.** (Preuss. Akad. Wiss. Berlin, Ber. 34. pp. 366–377, 1923. From the Reichsanstalt.)—The author describes an investigation of the earth's penetrating radiation at points very high above sea-level. He demonstrates the existence of a radiation of absorption coefficient $\mu_{H_2O} = 2\cdot5 \times 10^{-3}$ cm.$^{-1}$ at heights of 2300 and 3500 metres above sea-level. This radiation cannot be identified with any known γ-radiation from radio-active substances. It is shown that this radiation reaches a maximum at 8–9 o'clock and 20–21 o'clock daily, falling to zero at intermediate times. On this account it is suggested that the radiation has its origin in space outside the earth. A. B. W.

ASTRO-PHYSICS.

1099. *Proceedings of Observatories.* (Roy. Astron. Soc., M.N. 84. pp. 231–257, Feb., 1924.)—Reports from directors of several observatories. Part of the annual report of the Council of the Society. W. R. C.

1100. *New 60-in. Telescope for Perkins Observatory of Ohio Wesleyan University.* (Mechanical Engineering, 46. pp. 113–117 and p. 147, March 19, 1924.)—The instrument is designed by Warner and Swasey; the mirror is 60 inches in diameter and 9 inches thick at edge, weighing 2700 lbs. Two secondaries are a Newtonian (the diagonal flat) of 17·5-in. diameter, and a Cassegrain (convex mirror) of 16-in. diameter; these are readily removable. Provision is made for adding a spectroscope. A description is given of the general design of the polar and declination axes, the tube and driving clock, and the gearing by electric controls. The outstanding features are that four electric motors only are employed to give all the motions required; that in the telescope tube a much shorter over-all length can be used without reducing the focal length of the combination employed; that all motions in R.A. and declination are housed in the driving-clock unit and the declination axis respectively, so that the pier heads are reduced, making the bearings of the polar axis readily accessible; and that provision has been made for lubrication of all bearings. A. S. D. M.

1101. *Motion of Neutral Ionised Stream in Earth's Magnetic Field.* **S. Chapman.** (Cambridge Phil. Soc., Proc. 21. pp. 577–594, Nov., 1923.)—The author examines the mode of incidence upon the earth of a neutral ionised stream of matter from the sun, in connection with Lindemann's hypothesis [Abstract 445 (1920)] that if of suitable dimensions, speed and density, it could produce both magnetic storms and auroræ. The stream would become polarised in the earth's magnetic field, and the slight redistribution of charge would cause the resultant e.m.f.'s on the two sets of positive and negative charges to differ slightly, and the stream as a whole would be subject to a force having components both along and normal to its direction. This force is found to vary approximately as the inverse seventh power of the distance from the earth's centre, and would become appreciable only within a distance from the earth comparable with the earth's radius. The analysis is complicated and even after introducing simplifying assumptions, the author has found himself compelled to resort to numerical computation. It was fortunately found that the results obtained by restricting consideration to the two possible cases of plane motion, in the equatorial plane and in the meridian plane containing the sun, made it possible to indicate the character of the paths in the more general case. In both cases part of the stream is bent towards the earth and may impinge, nearly at grazing incidence, on the dark half of the earth. The bending is greatest where the density has a value of the same order as that considered by Lindemann. The speed of the stream does not affect the geometry of its motion. The bending, however, is not such as would suffice to account for auroral phenomena. If, therefore, the stream is to produce both auroræ and magnetic storms it cannot be neutral, and the resultant charge must exceed that which would arise in an originally natural stream by the mere leaking away of negative electrons. G. W. DE T.

1102. *Origin of the Solar System.* **J. H. Jeans.** (Nature, 113. pp. 329–340, March 1, 1924. Supplement. Discourse delivered at the Royal Inst., Feb., 1924.)—It is suggested that the course of stellar evolution can be traced in the heavens by arranging certain types in a regular sequence, the first stage being the elliptical nebulæ. These have been found by spectroscopic observation to be rotating rapidly, round their short diameter as axis. At the next stage the major axis is drawn out almost to points; then dark lines, and afterwards broad dark bands appear. This is evidently due to relatively cool matter projected against the hotter nucleus of the nebula, for this stage is the same, seen edgewise, as the spiral nebula, in which it has been found that matter is flowing outward from the nucleus along two arms. In later types the nucleus grows smaller and smaller, and the condensations which form on the arms become more detached and starlike. The density of the nucleus is estimated to be of the order of 10^{-16} g. per cubic centimetre.

This first part of the sequence is explained as follows: An elliptical nebula is a radiating rotating mass of excessively tenuous gas, and it must therefore contract and rotate ever more rapidly until it takes a lenticular form with a sharp circular edge for its equator; and now further speed in rotation will result in breaking up. Unless the nebula is perfectly symmetrical and the process quite undisturbed, which is improbable, gas will be ejected from two antipodal points, which represent the two points of high tide induced by some neighbouring body; and this outflowing gas will condense into globes, because on the immense scale of a nebula the mutual attraction of the particles overcomes the expansive influence of gas pressure. Dynamical theory enables us further to calculate the size, mass, and distance apart of these globular condensations: their mass approximates to the known mass of an average star, and the distance of the nebula deduced from their distance apart approximates to estimates made in other ways. A group of stars developed in this way may remain together and form a globular star-cluster, or it may scatter more or less widely, giving rise to star-streaming.

Each star continues to contract, and if the rotation is sufficiently rapid it will divide and become a double star; if still more rapid it will subdivide and finally become a multiple star; if rotation is comparatively slow, as with our sun, it will remain a single star. A planetary system cannot arise by fission, nor develop as stars develop from a nebula, because here gravitation is not strong enough to overcome gas pressure. But a disturbance from outside is indicated by the fact that the sun's plane of rotation differs from the plane of planetary orbits; and it is suggested that a near approach of another body raised tides on the evolving sun, so sudden and great that a jet of gas shot out massive enough to resist dispersion and to condense into small globes. The disturbance, growing and then diminishing as the two bodies came near and then moved apart, would give rise to a filament which would be thickest in the middle, thus explaining why the two giant planets Jupiter and Saturn have an intermediate position in our system. Satellites were produced by tides on the planets caused by the same great disturbance, or by the sun, or both, but theory shows that they can never have been gaseous, but that all the satellites and also the smaller planets must have been liquid or solid when formed. Details of size and position, and the number of satellites belonging to each planet are shown to be explicable on this tidal theory. It is the only theory not open to obvious and insuperable objections, although it is not claimed that it can account fully and finally for the evolution of the solar system.

The paper is illustrated by photographs of nebulæ and a star-cluster.
M. A. E.

1103. *Systematic Distribution of Solar Calcium Flocculi. Part II. Life-History of Bright Solar Calcium Flocculi.* **C. P. Butler.** (Roy. Astron. Soc., M.N. 84. pp. 134–149, Jan., 1924.)—The changes considered are *gradual* and *sudden*, and the flocculi are divided by the author for the purpose into (*a*) 14-day, and new formations; (*b*) births; (*c*) growths; and (*d*) deaths; the flocculi for 1912–1922 are tabulated, month by month, under the first three divisions, and show that bright calcium flocculi are much longer-lived than spots [compare Abstract 787 (1924)]; that there is no case of sudden extinction, all such are by gradual dispersion; that 14-day flocculi are usually greatly in excess of new formations, but near solar minimum this excess declines; that the process of formation from birth is very similar in all cases observed; that no spot is without accompanying flocculi, though there are often flocculi visible without accompanying spots, and especially in the period of minimum solar activity which can by this means be determined very accurately from the flocculi. [See also Abstract 2238 (1922).] A. S. D. M.

1104. *Variability of Solar Radiation.* **R. Lundblad.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 17. No. 14. pp. 1–57, 1922–1923.)—Comparison of existing theories with results of observation. The treatment of the subject is entirely mathematical and does not lend itself to a short abstract. E. F.

1105. *Sunspots as Magnets and Periodic Reversal of their Polarity.* **G. E. Hale.** (Nature, 107. pp. 105–112, Jan. 19, 1924. Supplement.)—The author traces the law of solar activity in the number, extent, and position of spots, and their changing angular velocity of rotation with their solar latitude; he examines the visual structure of spots showing an inflow which seems to indicate vortical motion; early spectroheliographic work on calcium H and K lines, or on hydrogen, H_β, H_γ, and H_δ lines, failed to indicate this vortical motion, but in 1908 at Mt. Wilson the hydrogen H_α line showed spots to be the centre of vast vortices. Since the sun is a hot gaseous body, there should be great numbers of electrified particles, both positively and negatively charged, and a preponderance of either charge in a solar vortex must give rise to a magnetic field, which was detected from observations of the Zeeman effect. Using a Nicol prism and quarter-wave plate over the slit on the iron line λ6173, it was seen that a spot showed N or positive polarity if the red component is transmitted, and S or negative polarity, if only the violet component. Observation confirmed that all spots contain magnetic fields whose strength is related, roughly, to the spot's diameter, and the polarities (with a few exceptions) follow a definite law according to the position of the spot north or south of the solar equator. If the sign of the dominant charge is the same throughout, the observed polarity depends on the direction of the whirl and may be likened to a terrestrial tornado (left-handed in the north, right-handed in the south). Solar spots tend to follow each other in pairs, and these pairs have their leading spots of one sign, their following spots of the other. From this, the author was led to look for and find " invisible " spots. Prior to 1912 the polarity of the preceding spots of a pair in the northern hemisphere was negative, and in the southern hemisphere, positive; subsequently to 1912 these signs were reversed, and in 1922 were reversed again. It seems probable that the dominant electric charge in all spot vortices is of the same sign, and remains so throughout, and that opposite polarities represent opposite directions of whirl, merely. The general magnetic field of the sun has shown no reversal of polarity. The vortices in hydrogen flocculi shown by H_α spectroheliograms is apparently a high level secondary phenomenon, and may perhaps be independent of the whirl of the spot vortex below it. A. S. D. M.

1106. *Two Relations between the Length of Day, Length of Year, Density and Mean Orbital Radius of Objects in the Solar System.* **C. della Salda.** (N. Cimento, 26. pp. 167–173, Oct.–Nov.–Dec., 1923.)—If ω is the angular velocity of rotation, Ω of revolution in an orbit, Δ mean distance from the centre, σ the density, certain relations appear graphically in the cases of Earth, Mercury, Venus, Mars, Jupiter, Saturn, Uranus, and the Moon. Plotting then Δ and ω/Ω a regular curve results and extrapolation gives the Neptunian day as 11–12 hours. Plotting $\omega/\Omega\Delta$ (which can be replaced by the equivalent quantities $\omega\Delta^{\frac{1}{2}}$ or $\omega\Omega^{-\frac{1}{3}}$) and σ gives another curve with Saturn as the only discordant point. These observations, besides their intrinsic interest, support Bielopolsky's determinations of the periods of rotation of Mercury and Venus and support the value doubtfully assigned to Uranus. A. Wh.

1107. *Cosmical Refraction.* **H. Kienle.** (Phys. Zeits. 25. pp. 1–6, Jan. 1, 1924.)—In Hopmann's address read in Bonn, September, 1923 [see Abstract 803 (1924)], he stated that the deflection of light in the neighbourhood of the sun, which was proved to exist by measurements of the 1919 and 1922 eclipse photographs, could be almost better explained by Courvoisier's " cosmical " or " yearly refraction " than by Einstein's gravitational effect. But the Courvoisier effect is not an established fact universally recognised by astronomers, and Harzer has shown that the circumsolar matter assumed to cause it would be totally inadequate to produce the required result unless it had properties contrary to all our experience. This fact was accepted by Courvoisier in 1913 (Beob.-Erg. der Kgl. Sternwarte zu Berlin, nr. 15), and further investigation into the " Courvoisier effect " should have been conducted, therefore, independently of the hypothesis of cosmical refraction. The effect is an apparent shift in stellar positions radially outwards away from the sun, diminishing with distance from the sun; and the observations on which Courvoisier founded his empirical formula were measurements made at various observatories of Venus near superior and inferior conjunction, and of some bright stars near the sun (absolute R.A. and Dec.). A critical examination of his figures, however, shows that they do not support the hypothesis of a yearly period, nor conform to the formula for distance from the sun. All that can be concluded from them is that there is a systematic error in meridian-circle observations, which tends to make morning determinations differ somewhat from those of the afternoon; and this may so well be due to some local cause, such as refraction in the air near the observer, or instrumental or physiological changes, all of which may be connected with the position of the sun, that it is unnecessary to seek a cosmical cause. The Courvoisier effect can have nothing to do with the shift in star positions on eclipse plates, which is determined by differential measurements. Hence there is no reason to hesitate in accepting the eclipse results as confirmation of the Einstein gravitational effect. M. A. E.

1108. *Momentum of Planets.* **C. Bellia.** (N. Cimento, 26. pp. 143–146, Oct.–Nov.–Dec., 1923.)—The momentum $2\pi k\,.\,m/\sqrt{a}$ is for Mercury $(0\cdot 09)\ 2\pi k$, for Mars $(0\cdot 0875)\ 2\pi k$, for Venus $(0\cdot 961)\ 2\pi k$, for the Earth $(1\cdot 009)\ 2\pi k$, for Jupiter $(139\cdot 67)\ 2\pi k$, for Saturn $(39\cdot 81)\ 2\pi k$, for Uranus $(3\cdot 326)\ 2\pi k$, for Neptune $(3\cdot 145)\ 2\pi k$. The planets therefore range themselves in five families, three of two each, two of one each. From the point of view of momenta, distances, and kinetic energy, the solar system presents remarkable analogies to the Bohr atom. A. D.

1109. *Absorption of Radiation Inside a Star. Part II.* **A. S. Eddington.** (Roy. Astron. Soc., M.N. 84. pp. 104–123, Jan., 1924.)—A theoretical investigation has recently been published by H. A. Kramers [see Abstract 863 (1924)] which has an important bearing on the problem of absorption and emission of radiation inside a star. The theory leads to formulæ for the intensity of the continuous X-ray spectrum and for the absorption of X-rays by expulsion of K and L electrons, which are in close agreement with laboratory results. At least part of the processes of energy-transfer in the interior of a star are of this nature, and the author considers it desirable to examine how far Kramer's theory elucidates the astronomical problem. Applying the theory to the star Capella, the author shows that an absorption coefficient is obtained about one-eighth that determined from astronomical observation. So far as can be ascertained this disagreement is outside the limits of uncertainty, but it appears difficult to be sure of this owing to the intricacy of the problem. The question whether Kramer's process is the principal process of energy transfer in the star is left open. The state of ionisation in Capella as examined in considerable detail and evidence is obtained that the mean molecular weight must be near $2\cdot 2$, a somewhat lower value than the author previously considered probable. [For Part I of this Paper see Abstract 1076 (1923).] A. B. W.

1110. *Study of Near-By Stars.* **W. J. Luyten.** (Harvard Coll., Obs. Annals, 85. No. 5. pp. 73–112, 1923.)—The author has made a list of all stars for which *any* value of the trigonometric, spectroscopic, dynamical, spectral, moving-cluster, or proper-motion parallax, exceeds $0''\cdot 099$; from these 105 are compiled whose proper motions are all known, and for some also, radial velocities and spectral classes. Analysing the distribution of these stars in space, according to Kapteyn's latest value for the density, there should be 190 stars in a sphere with radius of ten parsecs round the sun as centre. Dividing this sphere into ten concentric spherical shells, each with volume one-tenth that of the whole sphere, each shell should contain 19 stars; but the numbers actually found are: 22, 15, 7, 12, 12, 6, 6, 9, 8, and 8, showing that the density nearer the sun is rather higher than Kapteyn's value. More than one-half the mass of the Kapteyn system is contributed by stars of absolute magnitude between 4 and 9, and less than one-quarter by stars brighter than 3 or fainter than 10. The total mass per cubic parsec near the sun is 0·0246 times the sun's mass. Assuming that their centre of gravity is at rest, these stars (104 in number) give for the sun a velocity of 25 km./sec., directed towards R.A. 278°, Dec. + 36°. The distribution in direction of their corrected space velocities shows an axis of avoidance, and therefore a plane of preference which is parallel to that of the Galaxy. This preference does not correspond to the line of vertices of Kapteyn's star-streaming. In the stars actually used (83 in number) twenty have velocities exceeding 66 km./sec.; and Oort has suggested that as the lower limit of escape in the Kapteyn system is near 65 km./sec., such stars may not belong to our system, but it is improbable that they are really interlopers coming from another universe since their velocities tend to conform to our plane of symmetry. The author finds a close correlation between H and M where $H = m + 5 + 5 \log \mu$ and $M = m + 5 + 5 \log \pi$, meaning that the logarithm of tangential velocity progresses with the absolute magnitude. A functional relation is found between absolute magnitude and colour index (C_2/T), and linear diameter (D), and density (ρ), and he computes that for the Kapteyn System, the mass is $1{\cdot}4 \times 10^9$ the sun's mass, and the number of collisions (by analogy with a perfect gas) as $1{\cdot}4 \times 10^{-13}$. A. S. D. M.

1111. *Adiabatic Equilibrium of a Gaseous Star.* **A. Véronnet.** (Comptes Rendus, 178. pp. 692–694, Feb. 18, 1924.)—In the case of a star at a uniform temperature throughout, the density will attain a limiting value not far from the surface and then will be constant for 99 % of the radius. In the case of uniform density, the temperature will rise with increasing depth and will again approach a maximum value. A nearer approach to actuality will be the case of adiabatic equilibrium. If b is the co-volume of the gas, the differential form of Poisson's law will be $\frac{dp}{p} = \frac{C}{C-c}\frac{dT}{T} + \frac{db}{\gamma - b}$ and it is easy to obtain the relations:

$$\left(1 + \frac{p}{R}\frac{C-c}{C}\frac{db}{dT}\right)\frac{dT}{dr} = -\frac{\gamma\mu}{R}\frac{C-c}{C}\left(1 - \frac{\rho}{\rho_0}\right)$$

$$\left(1 + \frac{p}{R}\frac{C-c}{C}\frac{db}{dT}\right)\frac{d\rho}{dr} = -\frac{\gamma\mu}{R}\frac{c}{C}\rho\left(1 - \frac{\rho}{\rho_0}\right)$$

Here db depends only on T, μ is the molecular weight of the gas, and γ is the attraction at the radius r. Differentiating the second relation again and equating to zero, gives a possible equilibrium where a limiting pressure and temperature are approached rapidly but are not as high as in the extreme cases. It is pointed out that it is unwise to introduce hypothetical quantities in great excess of anything of which we have direct evidence. A. Wh.

1112. *Radial Velocities of Globular Clusters and de Sitter's Cosmology.* **L. Silberstein.** (Nature, 113. pp. 350–351, March, 8, 1924.)—The behaviour of two particles describing world geodesics is investigated and the assumption made by Weyl of a universal scattering tendency is

dispensed with. De Sitter's empty space-time is characterised by $ds^2 = \cos^2 \sigma \,.\, c^2 dt^2 - dr^2$ and $\sigma = r/\mathrm{R}$ where R is the curvature radius of the world. Then the radial motion of a free particle is $\frac{\mathrm{R}}{c}\frac{d\sigma}{dt} = \pm \cos\sigma\sqrt{1 - \cos^2 \sigma/k^2}$. The minimal lines (light signals) are $c(t - t_0)/\mathrm{R} = \int \sec\sigma \,.\, d\sigma$. Hence the complete Doppler effect will be $\delta\lambda/\lambda = k[1 \pm \sqrt{1 - \cos^2 \sigma/k^2}] - 1$ where $v_0 = c\beta$ gives $k = (1 - \beta^2)^{-\frac{1}{2}}$. For distant objects k is tentatively assumed to approximate to unity and finally $\delta\lambda/\lambda = \pm r/\mathrm{R}$. This result is compared with values derived from certain globular clusters, the values of R from seven cases being 6·7, 6·7, 2·2, 6·7, 4·7, 5·7, $9{\cdot}1 \times 10^{12}$ astronomical units. The agreement of these values is unexpectedly close and the author appeals for information concerning the radial velocities of the clusters N.G.C. 6293, 6553, 6779, 6864, 6981, 7006, and 7492, for which distance estimates are available.
A. Wh.

1113. *The Absorption of Light and the Limits of the Stellar System.* **H. Kienle.** (Zeits. f. Physik, 20. 6. pp. 388–393, 1924.)—The criterion proposed by v. Seeliger for the presence of a limit to the typical stellar system is stated by the present writer to have been much misunderstood. Van Rhijn's work is quoted, and also the recent publication of Kopff [see Abstract 53 (1924)], in which the deceptive effect on the Seeliger argument of a light-absorbing layer is pointed out. The investigation of this problem forms the subject matter of the present paper, and it is shown that Seeliger's assertion of regularity in the distribution of the star numbers does not produce discontinuity in the first differential coefficients, but that this effect only appears among the second coefficients. Also that such conditions can only be explained by the assumption of a finite limit to the stellar system and a finite maximum value for the absolute brightness of the stars. The paper is entirely mathematical.
H. H. Ho.

1114. *Constitution of Star Clusters.* **C. Parvulesco.** (Comptes Rendus, 178. pp. 375–377, Jan. 21, 1924.)—In a study of the double cluster in Perseus, the author has found that the magnitudes of the stars are related to their spectral types in a similar manner to that found by Adams in the neighbourhood of the sun—the farther from the centre, the more advanced the type; B-type stars being concentrated at the centre and K and M stars on the periphery of the cluster. There is, therefore, a relation between the cluster's centre of gravitation and the spectral types of the stars composing it. But in the cluster, mass is nearly uniformly distributed, so that each star is acted upon by a force proportional to the distance from the centre, from which he finds that the mean velocity (V_m) of a star is proportional to the amplitude of its motion, and that $m\mathrm{V}_m^2/2 =$ constant, so that the masses of the stars are in the inverse squares of their amplitudes. Since in this investigation it has been found that the amplitudes of motion of B, F, G, and K stars are equal respectively to 1, 2, 2·5, and 4, it follows that the masses of these types are as 1, 1/4, 1/6·25, and 1/16; that the most massive (B) stars have very small mean motions, and are not far distant from the centre. He therefore deduces that such a distribution is a law in such clusters as have a stratified structure.
A. S. D. M.

1115. *Algol Type Variables.* **Michcovitch.** (Comptes Rendus, 178. pp. 74–77, Jan. 2, 1924.)—Accepting Charlier's relation $r = \mathrm{R} \, . \, 10^{0\cdot 2m}$, where m is the apparent magnitude, r the distance, and R is a function of the temperature and diameter, which for certain types may be taken as constant for that type, the author investigates 152 Algol type variables. Of these, 18 have well-determined proper motions, and these give for the coordinates of the sun's apex and velocity, R.A. = 288°·7, Dec. = 18°·8, and S = 0″·342. Adopting, with Gyllenberg, the velocity of the sun as S = 4·17 siriometers, corresponding to 19·8 km./sec., R is found to be 2·51 sir. Presuming that all Algol type stars have the same absolute magnitude, from this it is possible to find their distribution in space, and the author finds that 60 % are nearer than 60 sir., and 78 % nearer than 100 sir., on one side or other of the galactic plane; in the plane their distribution is sensibly uniform up to 290 sir. Algols are therefore concentrated towards the galactic plane, though not to the same extent as B- or N-type stars. From the distribution in space of these stars, he derives a fresh determination of R = 2·46 sir., agreeing well with the previous value adopted. From the fact that 70 are stars of type A [wrongly given as type R in this paper, but corrected in the Comptes Rendus, Jan. 14, p. 348], the author checks the value of R = 2·07 found by Malmquist from the proper motions and radial velocities of 387 stars of similar type. A. S. D. M.

1116. *Absolute Magnitudes and Parallaxes of* 1080 *Stars.* **R. K. Young** and **W. E. Harper.** (Roy. Astron. Soc. Canada, J. 18. pp. 9–59, Jan.–Feb., 1924.)—The whole material of this investigation will eventually be published, but this is a preliminary paper designed to present without delay some of the main results. The general plan and the methods are described, and it is believed that the accidental error in the absolute magnitudes obtained is less than 0·2 M. Nine more lines have been added to the five previously used for judging ratios of line-intensity, and the character and behaviour of all are discussed, showing which are most suitable for use with different types of stars. The empirical curves connecting line-intensity with luminosity have been independently determined from about 500 stars whose trigonometrical parallaxes are known. Comparing the results of this investigation with those obtained at Mt. Wilson, the spectroscopic parallaxes found for stars of types F0 to G9 and also for the early K and the M types agree quite well; but for giants of the K3 to K9 types there is a remarkable difference, the Victoria observations showing a range of nearly five magnitudes, and the Mt. Wilson little more than one magnitude. It is thought that the criteria used at Mt. Wilson mixed together in one class stars of widely different luminosities. In the course of the work several more lines were noted which might with advantage be used in future determinations, since the greater the number of lines used the greater the reduction of accidental errors. There does not appear to be any sharp line of distinction in the absolute magnitudes of the c-stars, including Cepheids, and it is concluded that they form a part of the stellar sequence. M. A. E.

LIGHT.

1117. *On the Selective Reflection of Light at Diffuse Reflecting Bodies.* **G. P. Woronkoff** and **G. J. Pokrowski.** (Zeits. f. Physik, 20. 6. pp. 358–370, 1924.)—The problem of the diffuse reflection of light has up to the present not received a sufficiently clear and definite solution, and only the cosine law of Lambert has been established. In the present paper an experimental investigation of this problem is described with full detail, data being included for a variety of substances, *viz.*: Magnesium oxide, rust, rhodamine B, diamine red 4 B, diamine green, methylene blue, methyl violet B, crystal violet, and ultramarine. For bodies which absorb and diffusely reflect light a selective reflection has been observed. When the absorption is small, the reflection obeys the cosine law. When the absorption increases, then deviations are observed as the angle increases, and, for large reflection angles, the intensity of the scattered light deepens. The greater the absorption, the more distinct are the deviations from the cosine law. The Umow rule, which states a relation between the absorption and the polarisation of light rays, can be extended by the establishment of the connection between absorption, reflection and polarisation. In order to obtain the absorption spectrum which characterises the true colour of a given body, measurements must be carried out for incident and scattering angles smaller than 10°; or the investigation is so conducted that the reflected rays are allowed to fall on a nicol so arranged as to remove the polarised rays which exhibit the greatest deviation from the cosine law. To define a body optically it is necessary not only to have its absorption spectrum but also the curve for light scattering as dependent on the absorption and on the angles of incidence and reflection. H. H. Ho.

1118. *Variation of the Specific Refraction of Gases with Pressure below One Atmosphere.* **V. Posejpal.** (J. de Physique et le Radium, 4. pp. 451–460, Dec., 1923. Paper presented to Acad. tchèque des Sciences et des Lettres, June, 1923.)—It is shown, starting from the equation $n - 1 = K(1 + \beta p)$ where n is the index of refraction of a gas under pressure, that the values of the parameter β found by Safránek for oxygen and by Schacherl for hydrogen, below one atmosphere are numerically much greater than those which have been found by previous authors with higher pressures. Similarly to the case of air and of CO_2 formerly measured by the author, there is proved below one atmosphere an inverse proportionality between β and the mean value p of the corresponding interval of pressure, for higher intervals β diminishes more and more slowly with increasing pressures. For hydrogen the absolute value of β must be understood, its true value being negative. There follows from the values of the parameters β and from the experimental data on the compressibility of gases a variation of their specific refraction below, and sensibly little below, one atmosphere. The course of this variation as shown by curves is quite analogous to those found formerly for air and CO_2, with the single important difference that the curve for H has an inverse course. For the other gases the specific refraction increases with the pressure and very quickly for pressures very feeble, becoming constant at two or three atmospheres. The specific refraction of H diminishes in an analogous way with increasing pressure. A qualitative explanation of this variation of specific refraction with pressure is given founded on the ideas of the Rutherford-Bohr atomic theory. J. J. S.

1119. *Refractive Index of Gums and a Simple Method of Determining Refractive Indices.* **A. Mallock.** (Nature, 113. p. 159, Feb. 2, 1924.)—In connection with some work on the refractive indices of organic structures the author has measured the indices of a considerable number of gums and their solvents, data for which and experimental procedure being now given. It appears that no fluid (at least no fluid in ordinary use) has a lower refractive index than water. For a large number, μ lies between 1·35 and 1·45; for most of the gums soluble in alcohol, ether, or benzol, $\mu > 1\cdot45$ and $< 1\cdot55$, and for a few $\mu > 1\cdot6$. Between these and the μ for styrax (1·8) there is a large gap. **Erratum** (*Ibid.* p. 643, May 3, 1924). H. H. Ho.

1120. *Photometer for Surfaces of Low Brightness.* **G. Gehlhoff** and **H. Schering.** (Zeits. techn. Physik, 4. 10. pp. 391–392, 1923.)—Claims priority in the use of the Maxwellian view in photometry [see Abstract 1978 (1922)]. J. W. T. W.

1121. *Stellar Photoelectric Photometer.* **E. E. Cummings.** (Lick Observat., Bull. 11. pp. 99–121, 1923.)—A detailed account of apparatus designed for the 12-inch refractor of the Lick Observatory. The photoelectric cell, mount and string electrometer are all carried on the end of the telescope tube, and the necessary limitations of the design are discussed in some detail. The sensitive elements consist of potassium hydride in argon. Corrections are applied for dark currents, background illumination, zero shift and leakage, and the procedure in an observation is described. A colour index curve for the system is given, as well as an extended series of observations on β Cephei. This shows good agreement with the work of Guthnick and Prager, and the period given is similar to that derived by Crump from spectrographic data. The probable error of an observation is ± 0·008 magnitude. A. Wh.

1122. *Light Distribution.* **L. Bloch.** (Elekt. Zeits. 44. pp. 1071–1074, Dec. 13, 1923.)—Describes the usual methods of calculating mean spherical candle power or total flux from the polar curve of a light source. In the case of very uneven distribution, such as a lamp with focusing reflector, the use of a logarithmic candle-power scale is recommended. As a method of describing briefly the general nature of the light distribution from a source the use of the following three figures is recommended: (*a*) The position of the maximum candle-power, (*b*) the percentage of the total flux which is emitted in the lower hemisphere, and (*c*) the multiplication at maximum, *i.e.* the value of $J_{\text{max.}}/J_{\text{mean}}$. J. W. T. W.

1123. *Production of Thin Opaque Metallic Films and their Optical Properties.* **F. Rother** and **K. Lauch.** (Phys. Zeits. 24. pp. 462–464, Nov. 1–15, 1923.)—Describes apparatus which has been found suitable for the production of very thin opaque films of various metals on glass by kathodic sputtering. The metals which have been investigated are Ag, Au, Pt, Cu and Ni. The refractive index, absorption, and reflection ratio are given for light of wave-lengths 578 and 546 $m\mu$. J. W. T. W.

1124. *The Electric Birefringence of Camphor and Carvone.* **R. de Mallemann.** (Comptes Rendus, 177. pp. 1028–1031, Nov. 19, 1923.)—It has been shown in a preceding paper [see Abstract 1106 (1923)], that the measurement of the Kerr constant of an optically active body may not be carried out in general by the process usually employed for inactive substances, and a method for the purpose was then indicated. The present paper includes experimental details of the latter, and the results obtained thereby for camphor and carvone. The author concludes that solutions of camphor in hexane afford a remarkable verification of the principle of superposition enunciated by Gouy, in that the true birefringence is superposed simply on the normal rotatory power. Also the electrical birefringence of camphor is positive and sensibly independent of the concentration. Carvone is found to possess a much larger positive electrical birefringence, but its investigation is difficult because this liquid shows a persistent and appreciable conductivity. The type of phenomenon, however, conforms to the principle of superposition, but the maximum rotations of the axes of the ellipse have always appeared systematically greater than the calculated values. On theoretical grounds [*loc. cit.*] the orientation of the molecules by the electric field should suffice to render appreciable the anisotropy of their optical activity. The values of the Kerr constants found for camphor and carvone are + 159 and + 730 respectively, where $CS_2 = +100$, and $\lambda = 0{\cdot}546$. H. H. Ho.

1125. *The Butyro and Immersion Refractometers.* **J. W. Perry** and **C. C. Roberts.** (Journ. Sci. Instruments, 1. pp. 87–90, Dec., 1923.)—For many purposes results obtained with the butter and immersion refractometers are expressed in terms of the scale readings of the instruments; when necessary the refractive index of the specimen may be found from conversion tables. To test the consistency of these tables the relation between the scale reading and refractive index is determined for each instrument. The relations obtained show that errors in the scale calibrations are within the limits of accuracy claimed, but a small zero correction may be required for the former instrument. A. W. L.

1126. *Colour Vision.* **F. Exner.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 10. pp. 615–641, 1922.)—The question how the energy of the outer world is communicated to the nervous constituents of the retina has not been cleared up; the photochemical theory is not satisfactory; the Young-Helmholtz theory does not profess to offer a solution. The author assumes that the rods and cones are provided with damped electromagnetic resonators, each capable of responding to a considerable range of frequencies; and that normally these resonators are of three kinds, with ranges of frequency corresponding to red, green and blue-violet sensations respectively. He goes very carefully into the consequences of this assumption and into the facts of observation (including colour-blindness, rods and cones, twilight vision, eccentric vision, Purkinje's phenomenon, etc.), and he collates these. The time has not yet come for a complete systematisation; but nothing has emerged which tells against the resonator hypothesis, while this hypothesis greatly simplifies the whole subject. A. D.

1127. *The Faintest Visible.* **G. Jaeckel.** (Phys. Zeits. 25. pp. 13–17, Jan. 1, 1924.)—G. Gehlhoff and H. Schering have made measurements (Zeits. f. Beleuchtungswesen, 25. 17. 1919) according to which the limiting illumination of the retina which permits vision appears to depend on the visual angle subtended by the object; objects of 17″·5 require 2000 times the illumination required by objects of 1°; so that danger-signals ought to be large as well as bright. The author develops an explanation of this on physiological grounds. He assumes (1) a minimum amount of illumination must reach a given single rod of the retina, this amount being independent of the visual angle; (2) we must take into account the want of sharpness in retinal images, which reduces retinal illumination; (3) this want of sharpness is particularly marked when the eye is adjusted for darkness and the pupil dilated, and then the centre of a broad object appears brighter than the margin on account of overlapping. This is found to explain Gehlhoff and Schering's numerical apparent results, and also to explain irradiation; the margin of the retinal image is, at low illuminations, too feebly illuminated to stimulate the nerve-ends covered by it, while at higher illuminations the stimulus is sufficient. There is no need to assume a spreading of stimulus from rod to rod. A. D.

1128. *New Verification of the Law of Perception of Brief Illuminations at the Limit of their Range.* **A. Blondel** and **J. Rey.** (Comptes Rendus, 178. pp. 276–280, Jan. 14, 1924.)—In 1911 the authors published a law for determining the limiting range of brief illuminations under the form $Et = E_0t + K$, where E is the illumination of the pupil and t the duration of illumination, E_0 and K two constants. [Abstract 1476 (1911).] This law was established by numerous observations made by many observers. In 1920 H. Piéron described experiments tending to show that for durations of less than 0·1 second a certain "inertia of the retina" comes into play which would increase very considerably the value of Et in proportion as the duration of the flashes approaches more nearly to 0. The authors criticise the views and experiments of Piéron and have repeated some of their experiments with modified apparatus. The result is that they have verified the law previously established and have shown that it holds for illuminations still shorter than those they previously obtained. They find no new inertia of the retina to cause an increase of the product Et in the case of very short durations. In fact the effect of inertia is included in their formula in the constant K. For short durations the formula reduces sensibly to $Et = K$ (const.) as the old formula of Bloch.

J. J. S.

1129. *The Growth of the Telescope.* **W. J. S. Lockyer.** (Roy. Inst. Proc. Advance Proof. Received July, 1923. Nature, 112. pp. 284–288, Aug. 25, 1923.)

1130. *Focal Changes in Mirrors.* **E. Pettit.** (Mount Wilson Observat. Contrib. No. 266. Astrophys. J. 58. pp. 208–214, Nov., 1923.)—One of the chief difficulties in solar investigations is caused by the focal changes taking place in the image-projecting apparatus when the fixed form of telescope is employed. The object of the investigation described was to compare systems of mirrors in order to determine their relative merits. The mirrors were mounted on the cœlostats of the 150-foot tower, the 60-foot tower, and the Snow horizontal telescope and exposed to the sun. The position of the focused image of the sun was determined at intervals over a period of several hours by means of a card moved along a scale. Each pair of mirrors was tested on three or more days, and the mean curve drawn. Both long-focus lenses and concave mirrors were used to project the image. The observed focal changes are all reduced to the scale of the 150-foot tower telescope for comparison. Seven pairs of plane mirrors of crown glass, pyrex glass, and speculum metal, of varying thickness were used, with and without cooling systems. The smallest changes observed were with the speculum metal and the pyrex glass mirrors. For the first hour of exposure the rate of change in the pyrex mirrors is about the same as in the thick crown-glass mirrors of the towers, after which it ceases entirely and the focus remains constant during subsequent exposure. The same phenomenon was observed with the speculum metal mirrors, the focal change being slightly smaller. The effect of wind blowing on the mirrors is to reduce or even to reverse the march of the focal plane. All the mirrors tested, except the crown-glass mirrors of the Snow telescope cœlostat and the speculum metal mirrors became concave on exposure to the sun. This is an anomaly, since a convex figure would be expected to result from the linear expansion of the exposed surface. The seeing conditions at the 60-foot tower were found to be greatly superior to those at the Snow horizontal telescope on the 150-foot tower. As a result of the experiments described in the paper full-size pyrex mirrors have been obtained for the 150-foot tower. J. J. S.

1131. *The Thin Double Lens.* **T. Smith.** (Optical Soc., Trans. 25. 1. pp. 13–20, 1923–1924.)—The shapes of the lenses and the types of glass suitable for the construction of an objective free from all first-order aberrations in a primary plane for an infinitely distant object are found on the assumption that the system is composed of two separated thin lenses, each of which consists of glasses cemented together. The analysis indicates that "old" achromats should be used for both component lenses, a conclusion not in accordance with modern practice. AUTHOR.

1132. *Algebraic Theory of a Class of Photographic Objectives.* **E. T. Hanson.** (Optical Soc., Trans. 25. 1. pp. 1–11; Disc., 11–12, 1923–1924.)—After a short discussion of the general theory of the first-order aberrations in a system of thin lenses, the equations expressing the absence of Seidel's first four aberrations in an objective consisting of two thin systems of lenses, separated by an interval, are formed. When each of the two thin systems consists of only two lenses, the equations can be put in a form which admits of an elegant graphical solution, regard being paid to the necessity of obtaining a solution in which no one of the lens curvatures exceeds a certain limit. AUTHOR.

1133. *Interference Method of Determination of the Focal Length of Optical Systems.* **E. Bratke.** (Zeits. f. Physik, 21. 2. pp. 120–127, 1924.)—A method which permits of a high degree of accuracy is described for the determination of the focal length of a lens or a compound optical system. Light is reflected from the front and back surfaces of a plate of glass (optically plane-parallel and inclined at 45° to the axis of the lens system), through the lens system to a plane mirror the position of which can be adjusted. The light reflected by this mirror retraces its path to the plane-parallel glass plate and when the mirror is in correct adjustment forms a series of interference bands on a screen near the source. A small shift x in the position of the mirror produces a change from i_1 to i_2 in the distance apart of the interference bands. If λ is the wave-length of the light employed the focal length of the lens system is given by the expression

$$f = \sqrt{\frac{2a_0}{\lambda} \cdot \frac{x}{1/i_1 + 1/i_2}}$$

where a_0 is a constant $= \dfrac{d \sin 2\phi}{\sqrt{n^2 - \sin^2 \phi}}$ d being the thickness of the plane-parallel glass plate, n its refractive index, and ϕ the inclination to the optical axis of the lens system. As an example a telescope lens, not corrected chromatically, and having a mean focal length of 485 mm., gave

(a) $\lambda\, 578\, m\mu$ $f_0 = 487$ mm.
(b) $\lambda\, 546$ $f_0 = 485 \cdot 5$ mm.
(c) $\lambda\, 435$ $f_0 = 475$ mm.

The value of the focal length is that corresponding to the so-called axial rays (or rays of very small angular aperture). A. B. W.

1134. *Telescopic Triple Object-Glass of High Relative Aperture.* **J. W. Gifford.** (Roy. Astron. Soc., M.N. 84. pp. 175–177, Jan., 1924.)—Describes the construction of an apochromatic triple having a relative aperture $f/9 \cdot 2$. J. W. T. W.

1135. *Inter-Ocular Distance in the Binocular Microscope.* **H. Siedentopf.** (Zeits. f. Physik, 21. 3. pp. 178–186, 1924.)—As a result of the chromatic aberration in the eye, the apparent depth of an object seen by the binocular microscope depends on the colour of that object unless the inter-ocular distance is carefully adjusted to a particular value. It will be seen, by reference to Fig. 1 that if the light entering the left eye from a blue object be confined to the extreme left-hand portion of the pupillary opening, the image on the retina will be formed on the right (nasal) side of the line of sight. Similarly, if only the right-hand part of the right eye be effective, the image will again be on the nasal side of the fixation point. The result is an apparent displacement of the object away from the observer. Thus, if the inter-ocular distance be too great (see Fig. 2), blue objects will appear at a lower level than red objects which are actually in the same plane with them. J. W. T. W.

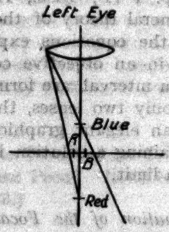


FIG. 1.

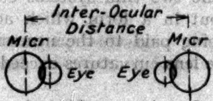
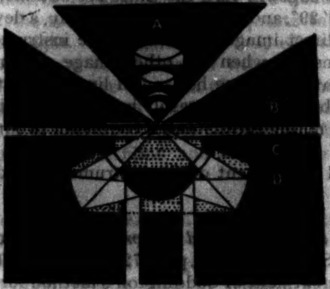


FIG. 2.

1136. *Focusing Type of Dark Ground Illuminator for High-Power Microscopes.* **C. Beck.** (Journ. Sci. Instruments, 1. pp. 148–149, Feb., 1924.)—Describes a dark ground illuminator which will focus through any slip from ½ to 1½ mm. thick. The back portion only is moved, while the lenticular front remains in immersion contact with the slide (see diagram).

J. W. T. W.



1137. *The Clairaut-Mossotti Objective.* **H. Chrétien.** (Comptes Rendus, 178. pp. 470–471, Jan. 28, 1924.)—The Clairaut objective and that due to Mossotti are compared, and it is shown mathematically why the latter have forms approximating to those corresponding to the double root of Clairaut's equation. W. V. M.

1138. *The Primary and Secondary Constant Magnification Surfaces of Thin Lenses.* **T. Smith.** (Optical Soc., Trans. 25. 2. pp. 89–95, 1923–1924.)—The surfaces of constant magnification on which the primary and secondary focal lines for a thin lens are situated form families of similar surfaces, and lie between easily constructed surfaces (spheres for the secondary surfaces) determined by the power of the lens together with the Petzval sum for the one limit and the sum of the lens curvatures for the other. AUTHOR.

1139. *Monochromator for* $200\,\mu\mu$ *to* $800\,\mu\mu$*.* **C. Leiss.** (Zeits. f. Physik, 21. 1. pp. 60–62, 1924.)—The author has previously described a simple monochromator for visible and ultra-violet light in the region $200\,\mu\mu$ to $750\,\mu\mu$. In the present paper another model for slightly extended wave-lengths and fitted with a wave-length drum is described. A diagram showing a horizontal section through this auto-collimation monochromator is given. [See also Abstract 2283 (1922).] A. E. G.

1140. *Design of a Prismatic Astrolabe.* **T. Y. Baker.** (Journ. Sci. Instruments, 1. pp. 65–74, Dec., 1923.)—A discussion of the design of the prismatic astrolabe, which has been found by geodetic surveyors to be capable of producing very accurate results in the determination of the latitude and longitude of a base point. The article refers specially to the instrument designed and manufactured at the Admiralty Research Laboratory, Teddington, which embodies two principal modifications of the original French instrument of Claude and Driencourt. Firstly, the prism is mounted so that it can be given successive rotations of 120° about an axis parallel to its edges so as to bring each in turn into the same position relative to the telescope. One angle of the prism was made as near 60° as possible, but of the others one is deliberately greater and one less. In using the edges in turn the times are obtained for star altitudes of 60° 7′ 38″, 59° 59′ 29″, and 59° 52′ 53″. Secondly, a device is incorporated to duplicate the direct image of the star, the instrument being used by determining the instant when the other image, moving in the opposite direction, comes into the same horizontal line as the two direct images. This method has been found to result in greater acuity of the eye than when it is a case of noting the instant of contact of two images approaching one another.

The errors and adjustment of the instrument are dealt with in some detail. M. A. G.

1141. *Testing of Right-Angled Prisms.* **J. W. Nicholson** and **F. J. Cheshire.** (Roy. Soc., Proc. 104. pp. 572–587, Dec., 1923.)—The authors give a theoretical treatment of Coddington's method for the determination of pyramidal error in a right-angled prism. A brief description is also given of the method as erroneously applied to the determination of error in the right-angle. The new method for the determination of both error and angular error is based on the optical arrangement shown in elevation in Fig. 1. The parallel beam incident on the right-hand face of the prism is focused to a definite point by the receiving system shown on the left. As the prism is rotated about a vertical line this image point moves in the focal plane and traces out a definite curve. This curve is of the form shown in six positions in Fig. 2. If O is the position of the image when the prism is removed, (1) and (1′) are the curves obtained from a prism without pyramidal error, but with inequality of base angles; (2) and (2′) are obtained with a prism having pyramidal error only; (3) and (3′) are given by a prism with both types of error. (They may alternatively be at P and Q.) The distances in the figure are, if f is the focal length of the receiver, $OA = f\eta\{\sqrt{2n^2-1}-1\}$ and $OB = f\epsilon\{\sqrt{2n^2-1}-1\}$ where η is the pyramidal error, ϵ the difference between the base angles, and n the refractive index. It is assumed in the above formulæ that η and ϵ are both small. J. W. T. W.

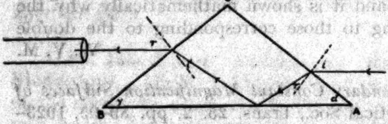


FIG. 1.

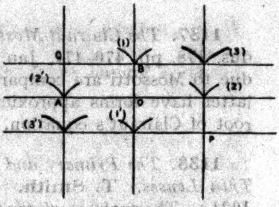


FIG. 2.

1142. *Physiological and Photographic Effects of Mercury-Vapour Lamps.* **M. Leblanc** and **Broca.** (Soc. Franç. Élect, Bull. 3. pp. 251–254, June, 1923.)—The author refers to an observation by Broca, who has found that the mercury-vapour lamp, in spite of its low brilliancy, causes a relatively great pupillary contraction which is ascribed to the fatiguing effect of certain radiation. Broca endeavoured to explain fatigue of the eye by monochromatic light by the Young-Helmholtz theory. In this connection the figures of Ives, showing the red, green, and blue constituents in various illuminants are quoted by the author, who contends that the resultant effect with quartz tube mercury lamps resembles that of daylight. In regard to actinic effect, experience shows that excellent photographs can be taken with light from such lamps. **Broca,** in reply, contends that the data of Ives are not in conflict with his hypothesis and that although good results are obtained with films taken by the light of mercury-vapour lamps much better ones are secured by using panchromatic films, and an exposure with light that is substantially white. J. S. D.

1143. *Total Reflection Prisms.* **H. Cranz.** (Zeits. Instrumentenk. 43. pp. 289–306, Oct.; 313–329, Nov., and pp. 341–351, Dec., 1923.)—A very detailed consideration of the geometrical optics of the different forms of total reflection prisms used in modern optical instruments. The paper is mainly mathematical and cannot be usefully abstracted. J. W. T. W.

1144. *The Waetzmann Interference Method for the Investigation of Optical Systems. Part I.* **E. Bratke.** (Zeits. f. Physik, 21. 1. pp. 9–25, 1924.)—Waetzmann, who used for the first time an interference method to determine the correction state of an image-forming optical system, found that the interference phenomena employed could be applied very well to qualitative observations of error. Deviations from the theoretical interference figures enabled estimations of the nature and magnitude of the errors and numerous applications were made to cases of spherical and chromatic aberration. For quantitative use, however, theoretical development is necessary, and this was supplied for the ideal case by Bratke and Waetzmann [see Abstract 473 (1924)]. The first part of the present investigation now deals with the theoretical extension to the ordinary lens combinations, and is followed by a comparison with the experimental data. Section 1 considers the appearance of the interference figures for lenses. Section 2 describes interference curves for optical systems of known spherical aberration. The unsymmetrical character of the curves is found to become less pronounced the smaller the spherical deviation of the system, and the thinner the plane parallel plate employed in the interference experiments. Further work is promised. H. H. Ho.

1145. *Kirchhoff's Theory of Diffraction.* **A. Rubinowicz.** (Ann. d. Physik, 73. 5–6. pp. 339–364, Feb., 1924.)—The intensity of the illumination behind a screen with a hole in it, illuminated by a point source of light, may be obtained by the Kirchhoff-Huyghens principle, as a double integral taken over the surface bounded by the edge of the hole. It is possible to reduce this to a line integral taken along the edge, and the author studies the approximate evaluation of this integral by use of the principle of stationary phase. The diffracted light can be expressed as due to a kind of reflection from points on the boundary in the neighbourhood of which the sum of the distances from the source and the point at which the illumination is sought has a stationary value. The approximation is taken as far as the cube term in the expansion of this sum as a Taylor's series. In the neighbourhood of the boundary of the geometrical shadow, the mathematics is more complicated, but the same physical interpretation holds. The method of approximation breaks down if the stationary condition holds for an extended range along the boundary; if the hole is very small; and for a boundary with points or cusps. W. G. B.

1146. *A Peculiar Diffraction Interference.* **K. Noack.** (Phys. Zeits. 24. pp. 495–500, Dec. 1–15, 1923.)—This paper deals with Maey's theoretical treatment of the author's previously described interference fringes at the edge of an illuminated screen (Phys. Zeits. 23. pp. 228–229, June 1, 1922), since certain features of it appear to contradict the results obtained. Discussion is confined to the case where the lens is focused as sharply as possible upon the objective picture of the screen edge. Two essentially different interference effects appear superposed on each other and these are considered at length from the standpoint of Maey's theory, tables of data being included. The primary fringes are found to be not equidistant but to decrease in breadth at first rapidly and then more slowly outwards, while in contrast the secondary fringes appear equidistant. These phenomena are considered for different screens, but further investigation is needed for a satisfactory solution to the various problems raised. H. H. Ho.

1147. *Remarks on K. Noack's Paper: "A Peculiar Diffraction Interference."* **E. Maey.** (Phys. Zeits. 25. pp. 17–19, Jan. 1, 1924.)—The writer commences by expressing his complete accord with Noack's observations [see preceding abstract], but points out the misunderstanding which underlies Noack's contradictory conclusions with respect to his (Maey's) previous work on the subject. In reply Noack, while requiring further experimental data, states definitely that for the explanation of the very sharp interference phenomena, two discrete sharp images are indispensable, and it is their absence which still leaves unexplained the fringes described by Maey. H. H. Ho.

1148. *Reflection and Transmission by Parallel Plates.* **F. Benford.** (Optical Soc. of America, J. and Rev. Sci. Inst. 7. pp. 1017–1025, Nov., 1923.)—Fresnel's reflection equations are used to obtain expressions for the light reflected from, and transmitted through, piles of plates, taking into account absorption in the glass. The cases of 1, 2, 3, and 4 plates in the pile are separately considered. By induction from these cases general expressions are obtained applicable to n plates. These general expressions are very complicated, however, and it is suggested that in any given case a step-by-step method should be adopted. A. A. D.

1149. *Photophoresis.* **O. Halpern.** (Ann. d. Physik, 73. 5–6. pp. 457–469, Feb. 1924.)—The radiometer theories of photophoresis (motion of illuminated particles) [Abstracts 1085 (1918) and 1616 (1920)] in their present form are able to give only a poor explanation of a number of important characteristics of the observations. The setting up of a thermodynamic criterion that may be modified in an analogous way for other radiometer phenomena gives first the reconciliation of the theory brought forward with the second chief proposition and leads secondly to the investigation of the hitherto not estimated temperature relations at the surface of the bulb. The enormous rise of temperature involved is not consistent with the observations and can scarcely be removed otherwise than by bringing in the auxiliary hypothesis of a condensation of gas. This hypothesis explains a series of thermal anomalies and gives at the same time a fixed point indicating in what direction the grounds for the bad agreement between theory and experiment are to be sought. Especially through it is the fact of the small dependence of the photophoretic force on pressure made understandable. J. J. S.

1150. *Polarisation of Light Diffused Laterally by Transparent Gases.* **J. Cabannes** and **J. Granier.** (J. de Physique et le Radium, 4. pp. 429–450, Dec., 1923.)—The partial polarisation of light diffused by the principal transparent gases normally to the primary beam has been examined several times. This phenomenon proves the anisotropy of the molecules and permits of the elimination of some of the proposed models. But the numerical values hitherto published present great divergences and the authors have made new measurements with care to obtain good conditions. When a transparent gas with polyatomic molecules is illuminated by a parallel beam of natural light, this beam observed laterally appears as a secondary source partially polarised. Two incoherent vibrations of unequal intensity constitute the diffused light. The stronger of the two vibrations, of intensity I, is normal to the plane of the two rays primary and secondary: the more feeble, of intensity i, is parallel to the primary ray. What is measured is the proportion of light polarised $(I - i)/(I + i)$ or more simply the ratio $\rho = i/I$, that is called the "factor of depolarisation." The most recent results of Lord Rayleigh give higher values than those previously published, and the authors after discussing various possible sources of error think that the most probable is that the gases were not perfectly clean but contained in suspension dust or minute drops which formed centres of diffusion. The authors have taken special precautions to obtain purity in the gases. They used (at Montpellier) sunlight as source of illumination which made easy good visual observations. Small quantities of gas—some hundreds of c.c. as a maximum—were used.

The following are the values obtained for ρ, the factor of polarisation, in the case of the various gases dealt with: N_2O, 0·122; CO_2, 0·098; O_2, 0·0645; Air, 0·041; N_2, 0·0375; NO, 0·026; H_2, 0·022; CO, 0·017. J. J. S.

1151. *The Electromagnetic Theory of Natural Rotatory Polarisation.* **H. Chipart.** (Comptes Rendus, 178. pp. 77–79, Jan. 2, 1924.)—In conformity with MacCullagh [see Abstract 827 (1924)] the dielectric polarisation P is deduced from the identity $\int(P\delta E)dw \equiv \int \delta W dw$, δE tending to zero value on the surface limiting the dielectric. W is a quadratic form of the components of the electric field E and its first differentials with respect to the coordinates. To find the double refraction and the natural rotatory polarisation, the two first terms only of the W series are considered, *i.e.* $W = \frac{1}{2}\phi(Ex, Ey, Ez) + \frac{1}{2}\psi(Ex, Ey, Ez; \partial E_x/\partial x, \partial E_y/\partial y, \partial E_z/\partial z)$, ϕ being a quadratic form and ψ a bilinear form. The latter contains 27 coefficients, and 9 linear equations are now shown to relate them. The quadratic form $\phi(Ex, Ey, Ez)$ is a direct scalar, and the polarisation P is shown to be the sum of two vectorial functions of E of which the first is derived from ϕ and the second from the above expansion. Invariant surfaces defining the optical properties of the medium are thereby derived. The paper is entirely mathematical. H. H. Ho.

1152. *Emission of Light from Excited Atoms.* **G. Mie.** (Ann. d. Physik, 73. 3–4. pp. 195–208, Jan., 1924.)—W. Wien explained the diminution of light emission along a canal ray, passing through a vacuum, as being due to the gradual fading away, "Abklingung," of the vibrations of the single atoms. Other more recent authors think of the emission of the atoms as an almost instantaneous process, and explain the above diminution as being due to the fact that the flashes of light are more frequent at first, but diminish as the number of excited atoms becomes smaller. The average time during which the atoms remain excited thus governs the above phenomenon. The author points out the difficulty of explaining refraction and interference on this theory, and propounds a theory of radiation, in which the atoms remain in the excited state for a finite time, and also send out light waves during a finite time. During this latter time the atom passes gradually from the higher stationary state to the lower, and thus spends a considerable period in non-stationary states; the further the momentary condition of the atom is from the final stationary state the stronger is the radiation; if the excess of energy of the momentary state over that of the final state is taken as a measure of the distance between the two states, it can easily be explained why the fading of the vibration obeys an exponential law. The essential difference between the non-stationary electron orbits and the stationary is that, in the former, the atom gives off energy by radiation; thus the non-stationary electron movements are not periodic, and it must be assumed that they do not obey the simple laws of classical mechanics. The sudden alterations which can take place in an atom owing to active collisions with other atoms, or to absorption of a radiation in resonance with the atom, are considered; they take place not only when the atom is in a stationary state, but when it is in the non-stationary states through which it passes during a spontaneous radiation of light. The final result of every sudden alteration is a stationary state of the atom; sudden alterations ("Sprunge," springs) of the first and of the second kind, must be distinguished, in the first of which the atom reaches the upper and in the second the lower stationary state. The time during which the radiations are sent out, "Abklingungszeit," is the most important factor in the experiments of R. W. Wood and of G. Cario, in which the light sent out by an excited metal vapour is destroyed by adding a neutral gas. Planck's formula follows from the various assumptions made by the author, using Einstein's method of proof, Einstein's magnitude, A_m^n, depending only on the time during which the atoms remain excited, "Verweilzeit." According to the ordinary form of the quantum theory A_m^n is equal to the reciprocal of the above time; on the assumptions made by the author, in the case that the two boundary conditions have equal statistical weight, A_m^n has half this value. H. N. A.

1153. *The Wladimir Michelson Principle.* **A. Perot.** (Comptes Rendus, 178. pp. 380–383, Jan. 21, 1924.)—Wladimir Michelson (Journ. de Physique, 10. 3rd ser. 150) enounced the principle that when, between a source of light and an observer relatively fixed with regard to one another, light traverses a medium whose refractive index varies with the time the wave-lengths are altered, just as when relative displacements of the source and the observer modify the wave-length. The author adduces experimental evidence in support of this principle. A. D.

1154. *On the Propagation of Light in Media with Periodic Structure.* **H. Chipart.** (Comptes Rendus, 178. pp. 319–321, Jan. 14, 1924.)—In his theory of double refraction and of natural rotatory polarisation, Sarrau deduced from considerations based on the periodic structure of the medium, the vectorial equality, $E=f_1(D, \partial D/\partial x, \partial D/\partial y, \partial D/\partial z)$. Potier's integration method giving more complete results, is now employed by the author to establish the vectorial equality, $P=f_2(E, \partial E/\partial x, \partial E/\partial y, \partial E/\partial z)$, P being derived from a potential. The paper is wholly mathematical. H. H. Ho.

1155. *The Radiation of Light.* **H. A. Lorentz.** (Roy. Inst. Proc. Advance proof. Nature, 113. pp. 608–611, April 26, 1924.)—The author points out the difficulties in the attempt to reconcile the modern views as to light quanta with the undulatory theory. The phenomena of photo-electricity seem to require that the energy of a quantum not only has a definite amount but also remains confined to a very small space so that an electron can catch at once a whole quantum. But there has to be faced a difficulty which hangs as a heavy cloud over this part of physics. The existence of narrowly limited disturbances of equilibrium is absolutely irreconcilable with the principles of the undulatory theory as embodied in Maxwell's equations of the electromagnetic field; and moreover the hypothesis of concentrated quanta is directly in contradiction with observed facts in the phenomena of interference. An observed interference phenomenon must be produced by *one* quantum, and interference fringes have been observed produced by rays whose path differed by more than a million wave-lengths, hence the length of a quantum in the direction of propagation must have been more than about 50 cm. That the lateral dimensions must be no less considerable is shown by the influence which the aperture of an optical instrument has on the quality of the images, and consequently on the resolving power. Michelson's experiments in which he measured the diameter of some stars indicate that a quantum must extend over a distance of 6 metres. The reconciliation of these well-established facts is an important problem for the physics of the future. It may consist in a certain return to a modified form of Newton's theory. The solution may be found in some happy combination of extended waves and concentrated quanta, the waves being made responsible for interference and the quanta for photo-electricity. J. J. S.

1156. *A Tentative Theory of Light Quanta.* **L. de Broglie.** (Phil. Mag. 47. pp. 446–458, Feb., 1924.)—In the present paper it is assumed that the light is essentially made up of light quanta, all having the same extraordinarily small mass. It is shown mathematically that the Lorentz-Einstein transformation joined with the quantum relation leads necessarily to the association of motion of body and wave propagation, and that this idea gives a physical interpretation of Bohr's analytical stability conditions. Diffraction seems to be consistent with an extension of the Newtonian dynamics. It is then possible to save both the corpuscular and the undulatory characters of light, and, by means of hypotheses suggested by the electromagnetic theory and the correspondence principle, to give a plausible explanation of coherence and interference fringes. Finally, it is shown why quanta must take a part in the dynamical theory of gases and how Planck's law is the limiting form of Maxwell's law for a light quanta gas. The author opines that little doubt should remain of the real existence of light quanta. Moreover, if these opinions are received, since they are grounded on the relativity of time, all the enormous experimental evidence of the quantum will turn in favour of Einstein's conceptions. An appended note contains a more general form of the result that the rays of the phase-wave are identical with the paths which are dynamically possible, and the identity of the two principles of Fermat and Maupertius is shown to follow whereby it becomes possible to deduce rigorously the velocity of the phase-wave in any electromagnetic field. H. H. Ho.

1157. *On the Sensitivity of the Silver Halide Grains of a Photographic Emulsion.* **W. Clark.** (Phot. J. 64. pp. 91–96; Disc., 96–97, Feb., 1924.)—Reference is made in the introductory remarks to the results of previous work on this subject which indicated that treatment of a photographic plate with a desensitising agent, such as chromic acid, brought about an increase in the gamma of the plate; this increase was believed to be due to an increase in the proportion of grains of equal sensitivity, owing to the destruction of the specially sensitive points in the grains. The present paper deals with the effect of desensitisers on single-layer emulsions of one-grain class, and with the action of chromic acid on one-grain-layer plates. Details of the method of working are given and tabular and graphical results presented. The logarithm-exposure-density curves indicate a general and marked reduction in grain sensitivity as a result of treatment with chromic acid, the curve of the desensitised emulsion being shifted bodily along the exposure axis. Chromic acid brings about a decrease in the *total range* of sensitiveness of the grains of an emulsion, but not in the " tangent " range, the former being most marked in the regions of higher exposure. The effect of exposure of a preliminary nature, on the desensitisation by chromic acid was also investigated by the author, and it is shown that treatment of a fast plate with chromic acid solution after a preliminary exposure, reduces the speed to a minimum of 5 H and D; by exposure to light preliminary to treatment with chromic acid the time of desensitisation is reduced enormously. The single-layer action results mentioned indicate that the gamma is unaltered if sufficient treatment with the desensitiser is given, but the total range of the curve is decreased owing to decrease in the range of the fully exposed portion. The general increase in gamma brought about by treating a finished plate with chromic acid is due to the range decrease in the sensitivities of each grain-size class. In an emulsion, for a given treatment, the smaller grains are relatively more desensitised by chromic acid than the larger ones. Preliminary exposure increases the rate of decrease of sensitivity the effect being more marked with the fastest and absent in the slowest or process plates. Preliminary exposure to sodium arsenite solution has the same effect as light in increasing the rate of desensitisation. [See also Abstracts 853 (1921) and 1013 (1924).] A. W. J.

1158. *Speed of Photochemical Reactions under the Action of Light of Periodic Intensity.* **P. Lasareff.** (Comptes Rendus, 177. pp. 1436–1438, Dec. 26, 1923.)—According to the law known in optical physiology as Talbot's law the speed of photochemical reactions produced by continuous sources of light, and by light of periodic intensity, is the same if the energy absorbed during a period of variation of the light is equal in the two cases. In the present paper a generalised mathematical treatment is developed in which the main assumption is that photosensitive reactions may be regarded as composed of a pure photochemical reaction and a thermic reaction. The results show that Talbot's law can be regarded as an exact law, and experiments carried out in connection with coloured vision are stated to afford complete confirmation of the law. **Errata** (*ibid.* 178, p. 432, Jan. 21, 1924). A. B. C. L.

1159. *Phosphors and Stokes's Rule.* **B. Gudden.** (Phys. Zeits. 24. pp. 465–467, Nov. 1–15, 1923. Paper read before the Physikertag, Bonn, Sept., 1923.)—Many examples among phosphors adverse to Stokes' rule. The photoluminescence in these must occur at the cost of molecular energy. A. D.

1160. *The Fluorescence of Certain Organic Compounds.* **E. Bayle** and **R. Fabre.** (Comptes Rendus, 178. pp. 632–635, Feb. 11, 1924.)—The tints of fluorescent compounds can be used to separate them in mixtures in which it is difficult to do this by ordinary analytical processes; thus novocaine, which gives a very intense fluorescence in ultra-violet radiations, can easily be separated from cocaine or stovaine, which are not fluorescent, the individual crystals being picked out from a mixture by means of forceps. A number of other organic compounds have been investigated, including salicylic acid and its derivatives, using the 3650 mercury ray; the results are given in a table, with columns for the colour of the fluorescence, the dominant wave-length of its spectrum, and the intensity. The authors attempted to determine the curve of energy distribution with the spectrophotometer, but in no case found the intensity of the fluorescence sufficient for this; they found the dominant wave-length by placing the substance, compressed into a pastille, at the focus of the adjusting telescope of the spectrophotometer, and exciting it with the Hg light; the field of view of the telescope was then compared with that produced in the comparison telescope by the different regions of the spectrum due to a small incandescent lamp, and a match of colour was obtained; this can be done to within 10 Å. to 50 Å., according to the complexity of the tint. To estimate the intensity the pastilles are placed side by side and compared, the intensity of salicylate of soda being taken as 20. Liquid compounds were examined in quartz tubes. It is proposed to continue the experiments, using other wave-lengths for the exciting light. H. N. A.

1161. *Time Lag between Excitation and Emission for Certain Fluorescent Solids.* **P. F. Gottling.** (Phys. Rev. 22. pp. 566–573, Dec., 1923.)—The work begun in 1921 by R. W. Wood on the measurement of fluorescent intervals and phosphorescent times has been continued. The method of Abraham and Lemoine, somewhat modified, was used for determining the very short periods of time involved. The fluorescent light is polarised and then passed through a condenser, containing nitrobenzene as dielectric, which had begun to be discharged when the illuminating spark started. The later the light arrives the lower the average field of the condenser and the smaller the angular setting of the analysing nicol to match the two images produced by a double-image prism. The apparatus was calibrated by means of light reflected from a mirror at different distances from the spark. The interval of time between the occurrence of a spark and the emission of the fluorescent light excited by that spark, was found to be $(2{\cdot}12 \pm {\cdot}01) \times 10^{-7}$ sec. for barium platino-cyanide and $(2{\cdot}11 \pm {\cdot}14) \times 10^{-8}$ sec. for rhodamine. AUTHOR.

1162. *Some Aspects of Modern Spectroscopy.* **F. A. Saunders.** (Science, 59. pp. 47–53, Jan. 18, 1924. Address to the Am. Assoc. for Advancement of Science, Ohio.)—A general consideration of series spectra in the light of atomic structure theories due to Bohr and Lewis. The fundamental difference between the two theories suggests that an electron's position is given by the orbit as a whole rather than the instantaneous position of the electron itself. Magnetic phenomena have not received sufficient attention and may account for the fundamental tendency of electrons to form pairs. An account is given of the pp' groups of Be, Mg, Ca, etc., it being shown that these groups belong to a spectrum series of their own, but that the terms of some of them are negative, the extra energy lying in other electrons.

Curves showing the ionisation potentials and atomic numbers of the elements are given, the extraordinary stability of the inert gases being clearly brought out. Arrangement of the potentials according to the columns in the periodic table shows parallelism between them, and there is on the whole a rise of ionisation potential with the number of external electrons between one alkali metal and the next inert gas, again evidence of the tendency in electrons to pair. The value for C (7 to 8 volts) is confirmed and indicates no very great strength in its tetrahedral structure.

A general account is given of Fowler and Paschen's work on silicon and aluminium, concluding an interesting semi-popular survey of modern spectroscopy. M. V. M.

1163. *Co-Ordination of the Complex Structure Terms, in Strong and Weak External Fields.* **W. Pauli, Jr.** (Zeits. f. Physik, 20. 6. pp. 371–387, 1924.)—In an earlier investigation [see Abstract 2425 (1923)] it was shown that the Zeeman terms in strong magnetic fields could be classified by two quantum numbers μ and m_1, whose sum is equal to the Landé quantum number m. On the other hand in weak fields, the terms of a definite multiple are distinguished by the quantum numbers j and m. Corresponding terms in strong and weak fields thus have the same value of m. In the above work, however, the coordination question remained open, and a recent discussion by Landé [Abstract 528 (1924)] has provoked the present paper which goes into the problem at length. The paper, which is entirely mathematical, describes a model for the purpose of coordination, which is superior to the existing method of involving a discussion of the integrals $\int p_k d\phi$, where p_k and ϕ are the canonical coordinates. H. H. Ho.

1164. *Spectra of the Lighter Elements.* (Nature, 113. pp. 217–224, Feb. 9, 1924. Supplement. Discussion in Sect. A of the Brit. Assoc., Liverpool, 1923.)—**J. C. McLennan.**—Optical spectra originate in displacements of the outermost electron in an atom or atom-ion of an element. To determine the structure of the lighter atoms it is important to determine spectra between the highest limit attainable by the use of crystals and the lowest limit by ruled diffraction gratings. Various workers have used the latter method and Millikan has photographed a line of aluminium, at 133 Å. Between this limit and 13 Å., the longest X-ray wave-length measured by crystals, the quantum relation $Ve = h\nu$ must be used, and Holweck has determined the mass coefficients of absorption for thin celluloid and gases for all wave-lengths from 1140 Å. to 10 Å. A photoelectric method has also been used by several workers which consists in measuring the electric field applied to an electron stream which will cause the element bombarded by these electrons to emit their characteristic radiations. Tables are given of the results obtained.

R. A. Millikan.—In the author's opinion it is proved that the L_a series continues with its main characteristics unchanged throughout the range of atomic numbers from uranium (92) to neon (10), and that gaps occur in optical spectra as in X-ray spectra. Thus for aluminium there are no lines between 144·3 Å. and about 1200 Å. Lines in the L spectrum of sodium and magnesium predicted by the Bohr theory have been found, as well as lines of aluminium and silicon corresponding to atoms which have lost all their outer electrons predicted by Paschen and Fowler respectively. The author believes that the lines he identified as L_a lines of boron, oxygen, nitrogen, and fluorine are due to atoms which have lost all valency electrons.

A. Fowler.—The arc spectra of the elements show a remarkable alternation of doublet and triplet series from group to group of the periodic table. The spark spectrum of an element is of the same type as that of the arc spectrum of the preceding element. The atoms giving the spark lines have therefore the same distribution of electrons as the neutral atoms of the element of atomic number one smaller. The series constant for such singly ionised atoms is 4 R (*i.e.* four times the hydrogen constant). Theoretical reasons are given for expecting the alternation of spectra mentioned and also the establishment of series with constants 9 R and 16 R for multiply-ionised atoms. Such series have been found and the correspondence in the abnormality of the diffuse triplets of Si(III) and Al(II) noted. With increase in ionisation corresponding lines are displaced to shorter wave-lengths and their separation increased. There is no reason to suppose that process of ionisation should stop when all the outer ring of electrons is removed. Some inconsistencies in the choice of L_a lines for the light elements made by Millikan are noted. A far more extended knowledge of the series arrangements in the spectra of elements is required.

N. Bohr.—The quantum theory of atomic structure rests upon the assumption of a manifold of so-called stationary states. The laws of classical mechanics are unable to account for the existence and stability of these states, but a theory has been developed which gives the properties of an atom with one electron. A principal source of information in regard to atomic structure is found in series spectra. Results for excited molecules emitting band spectra may be expected to be similar to those for excited atoms emitting series spectra. Fowler's work on the band spectrum of helium has confirmed this. **D. Coster** gave a detailed account of his work with Bohr. He had deduced that the element hafnium, atomic number 72, belonged to a new group of elements and not to the rare earths. He used a photometric method of determining the percentage of hafnium present in ores and checked it by adding known amounts of tantalum. **H. Robinson** referred to his work by the photoelectric method in which the element in question is illuminated by homogeneous X-rays and the velocity of emitted electrons measured by magnetic deflection. An accuracy of one in a thousand may be obtained in relative measurements.

F. S.

1165. *The Height in the Chromosphere of Resonance Lines.* **F. Croze.** (Comptes Rendus, 178. pp. 200–202, Jan. 7, 1924.)—In a previous note

[Abstract 841 (1924)] the author has suggested that when the spectrum of an element contains several systems of series, the " raies ultimes " are the resonance lines which belong to the same series; *i.e.* lines formed by jumps from an outer orbit to the normal inner orbit are only " raies ultimes " if both the orbits belong to the same series system. He now seeks to obtain corroborative evidence from Mitchell's observations on the heights in the chromosphere at which different lines of different elements are observed [see Abstract 616 (1914)[, in the light of Saha's theory. As the height in the chromosphere increases, the density of any element will decrease, so that at the greatest height at which an element occurs, the lines to be expected would be the " raies ultimes." This is observed for chromium, magnesium, and manganese; *e.g.* in Mg the line $1S$–$2p_2$ (λ4571) corresponds to a jump from the succeeding outer orbit to the normal inner orbit, and yet this line occurs at heights not greater than 400 km., while the triplet $2p_i$–$3d$ occurs at 7000 and 6000 km. A. C. M.

1166. *Intensity Distribution, Term Sequence, and Exciting Function in the Spectra of the Alkali Metals.* **H. Bartels.** (Zeits. f. Physik, 20. 6. pp. 398–412, 1924.)—The work of Franck, Hertz, etc., has shown that to every energy surface in the atom there corresponds a definite activating potential. Only electrons whose volt velocities equal or exceed this potential are in a condition to excite the corresponding energy surface by impact. During impacts, however, a large part of the energy is purely elastic, so that only a fraction serves for the activation of the atom, and Seeliger has derived an expression relating the degree of the latter with the volt velocity [see Abstract 1503 (1919)]. In the present paper it is shown that by two simple assumptions a close relationship exists between the exciting function of the separate energy levels and the term system of the atom concerned. The consequences involved for the intensity distribution in the spectrum are now established for the spectra of the alkali metals, since here the relationships are especially favourable on account of the simple term schemes, the known intensity distributions, and the comparisons afforded by 5 similarly constructed spectra. The above assumptions are: (1) Impacts between atoms and electrons of given volt velocity proceed either elastically or by the activation of the energy surface at which the electron loses the most energy. (2) Activation by electronic impact is the equivalent of emission with respect to the azimuthal quantum numbers. The paper consists of a continuous physical argument and must be consulted in its entirety. H. H. Ho.

1167. *The Absorption Spectra of Mixed Metallic Vapours.* **S. Barratt.** (Roy. Soc. Proc., 105. pp. 221–225, Feb. 1, 1924.)—A new band spectrum is described which is developed only in the vapour of mixtures of sodium and potassium and which, it is suggested, is produced by the sodium-potassium molecules present in the mixed vapour. The metallic vapour was maintained in a steel tube heated electrically, the continuous background being provided by the positive crater of a carbon arc. On heating a mixture of roughly equal proportions of the two metals in the furnace, a new band absorption was observed in the yellow, reaching from the red side of the widened D lines to about λ5650. This comprises a series of bands degraded towards the red and spaced at intervals of about 20 Å., each band consisting of fine lines, separated in the middle of the band by intervals of a few Ångstrom units but much more closely packed near the head. The heads are arranged according to the usual Deslandres law. Principal series absorption has no connection with the production of this spectrum.

Mixtures containing magnesium have also been used and λ4571 has been continually observed in accordance with quantum considerations and in opposition to McLennan, who failed to observe this line under similar conditions. W. V. M.

1168. *Fluorescence Spectra. Part. II. Phenol and Phenolic Ether Vapours.* **J. K. Marsh.** (Chem. Soc., J. 125. pp. 418–423, Feb., 1924.) —The fluorescence spectra of the vapours of phenol and the phenolic ethers have been investigated, using the same apparatus as in Part I. [see Abstract 846 (1924)]. The results are given diagrammatically, though intensities are not to be relied upon for comparison. There is a marked similarity in the spectra of all the phenols and phenolic ethers. They commence near to 280 $\mu\mu$, attain a maximum near to 290 $\mu\mu$, and then gradually dwindle away to the neighbourhood of 370 $\mu\mu$. In some cases, there is in addition a second fluorescent region in the blue, probably connected in some way with the first region. In phenyl mercaptan, this second region alone appears. The properties connected with this second region are (*a*) weight of side-chain, (*b*) residual affinity in the side-chain, and (*c*) ortho-substitution.

Distinct banding is found only in phenol and anisole, and a comparison table is given, which brings out a clear parallel between them, while no definite agreement is found with the benzene bands in the same region.

In the cresols there is evidence that the fluorescence increases in the order: ortho, meta, para. Para-substitution is least destructive to the benzene band system. In general, the fluorescence region is of shorter wave-length than the absorption region; but the three least refrangible bands in the fluorescence spectrum of phenol are to be identified with the three most refrangible bands in its absorption spectrum. It is pointed out in conclusion that fluorescent vapour spectra should be least complicated by mutual molecular disturbance since the substance is vaporised. A. C. M.

1169. *Absorption Spectra of the Halogen Halides.* **H. Bell.** (Phil. Mag. 47. pp. 549–560, March, 1924.)—The absorption-band spectra in the infra-red of the halogen hydrides HF, HCl, HBr have recently been determined very carefully by several investigators. In this paper the experimental data have been analysed with the aid of the energy-formula developed by Born and Hückel. It is shown that the values of the coefficients in the formula, $1/\lambda = C_0 + C_1m + C_2m^2 + C_3m^3$, which embodies the experimental results for the main band and its overtones are, within the limits of experimental error, consistent with theory. The accuracy is not sufficient, however, to decide whether the "zero-point energy" exists or not. The significance of the constants in the formula is discussed. Their determination makes it possible to evaluate the variation with distance of the force acting on the hydrogen nucleus as it vibrates along the line joining the two nuclei. The range of vibration for one, two, and three energy quanta is calculated. A note from D. R. Hartree on the dimensions of the Cl-ion concludes the paper. H. H. Ho.

1170. *Radiation Potentials of Atomic Hydrogen.* **P. S. Olmstead** and **K. T. Compton.** (Phys. Rev. 22. pp. 559–565, Dec., 1923.)—Atomic hydrogen was produced by thermal dissociation of molecular hydrogen with a tungsten furnace which could be maintained at 2800° K. during observations. Electrons were emitted from an equipotential oxide-coated platinum rod thrust into the furnace. Radiation was excited by electrons falling through an accelerating difference of potential between the rod and the equipotential tungsten cylinder forming the wall of the furnace, and was detected by its photoelectric action on a platinum disc placed beyond the open end of the furnace. This disc was shielded from ions produced in the furnace by an intervening set of charged plates. Radiating potentials were observed at 10·15, 12·05, 12·70, 13·00, 13·17, 13·27 volts, with additional radiation at the ionising potential 13·54 volts. Within the probable error of the observations, less than 0·05 volt, the agreement with the Lyman spectral series and with the Bohr theory is exact. AUTHORS.

1171. *Behaviour of the Line Spectrum of Hydrogen at Low Temperatures.* **L. Citron.** (Ann. d. Physik, 73. 5–6. pp. 470–476, Feb., 1924.)—The many-line spectrum of hydrogen is interesting on account of possible inferences as to the structure of the molecule, and the author examined it as produced partly in the capillary, partly in the positive column of the Geissler tube when this was surrounded by liquid air, and compared its appearance with that at ordinary temperatures and noted the changes of intensity produced. The results are arranged in four groups according to the amount of the change produced by low temperature. But these changes differ much amongst themselves and it is not possible to arrange the results in a series whose individual vibration numbers show a systematic connection. Also a comparison with the other investigated characteristics of the line spectrum—Zeeman effect, Stark effect, and intensity changes with high potential and with mixture of helium—had no success. J. J. S.

1172. *Ultra-Violet Absorption Spectrum of Ammonia Gas.* **Ferrières.** (Comptes Rendus, 178. pp. 202–205, Jan. 7, 1924.)—The absorption of ammonia in the ultra-violet was measured by a photographic method. The absorption spectrum is made up of a series of triplets following a regular law. Except the first, all have for mean frequencies numbers of which the successive differences are not far from 900. The absorption commences about 2265 Å. and increases very rapidly as the wave-length diminishes. About 2100 Å. a thickness of 1 cm. of ammonia gas at atmospheric pressure is sufficient to reduce to less than $\frac{1}{200}$ the intensity of the incident radiation. J. J. S.

1173. *Continuous Spectrum of Hydrogen.* **H. B. Lemon.** (Nature, 113. pp. 127–128, Jan. 26, 1924.)—The continuous spectrum of hydrogen is observed in discharge tubes having a hot kathode operating at 100 volts, with unusual intensity up to the yellow-green. The discharge appears a bright blue, but this is apparently synthetic, since the spectrum is not particularly strong in this region. The kathode was a braided platinum filament coated with oxides of strontium and barium, and capable of delivering up to an ampere. The anode was about 10 cm. distant. The Balmer series alone comes out when the filament current is low; higher filament current brings out the secondary spectrum, and still higher filament current excites the continuous spectrum; the observation is made in the region immediately in front of the kathode.

Photographs of the glow and of the spectrum of the glow are given when each of the three conditions obtains. A. C. M.

1174. *Extension of Extreme Ultra-Violet Spectra of Lead, Bismuth, Antimony, and Thallium.* **L.** and **E. Bloch.** (Comptes Rendus, 178. pp. 472–474, Jan. 28, 1924.)—Previous measurements have been repeated using the spark in an atmosphere of nitrogen and the recent improvements which allow of extension to 1300 Å. Tables are given of 23 new lines for lead, 11 for bismuth, 20 for antimony, and 14 for thallium. A certain number of lines appear to be spontaneously reversible, most of which seem to coincide with arc lines found by McLennan. It is suggested that for the time being such reversibility be used as a test for arc lines in this region. F. S.

1175. *Spark Line in the Lithium Spectrum.* **F. L. Mohler.** (Science, 58. pp. 468–469, Dec. 7, 1923.)—An attempt was made to excite the spark lines of lithium by using the discharge from a hot kathode in lithium vapour at low pressures, as these conditions have been found good for the excitation of spark lines in other elements.

The spectra were photographed with a large Hilger quartz spectrograph. A line was found at about $\lambda 2934 \cdot 15 \pm 0 \cdot 1$. It was found in one very long exposure with an excitation potential of about 45 volts. From other considerations the excitation potential should be about 50 volts with an error greater than 5 volts. The spark spectrum of lithium should, of course, resemble the arc spectrum of helium. It is suggested that λ2934 may correspond to the helium doublet $2s - 2p_{1,2}$. An unusual development of the subordinate series was observed in these photographs. A. C. M.

1176. *The Mass of the Particles which Emit Various Band Spectra Attributed to Nitrogen.* **H. M. Duffieux.** (Comptes Rendus, 178. pp. 474–476, Jan. 28, 1924.)—Nitrogen emits several band spectra of very different structures: (1) A positive first group containing numerous very complex bands; (2) a second positive group; (3) a negative group emitted by the kathode glow; (4) bands supposed to be due to cyanogen but which recent work show to be due to nitrogen.

The study of the order of the limits of interference shows that the second positive group is due to the atom of nitrogen. The same method applied to other groups shows that: (1) The negative group is emitted by the atom of nitrogen, (2) the cyanogen bands cannot be emitted by a molecule but are due to atoms of nitrogen, (3) while the first positive group is emitted by molecules. W. V. M.

1177. *Alterations in the Nitrogen Band Spectrum.* **W. Steubing** and **M. Toussaint.** (Zeits. f. Physik, 21. 2. pp. 128–137, 1924.)—A continuation of recent work [see Abstract 506 (1924)] using the same apparatus. It is shown when large quantities of ionised argon are mixed with nitrogen that marked variations are produced in individual band groups of the nitrogen spectrum. A similar effect, but quantitatively and qualitatively smaller, is produced by strongly ionised neon. Other elements, whether of higher or lower atomic weight, and either electropositive or electronegative, produce no such result. The variations have nothing to do with the temperature of the radiating gas, such temperature effect being of a different kind and independent of the other. The alterations are attributed to a change of configuration of electrons in the atoms of the inert gases by the intense ionisation applied. F. S.

1178. *Origin of Certain Lines Attributed to Oxygen.* **W. Jevons.** (Phil. Mag. 47. pp. 586–590, March, 1924.)—Certain lines in the ultra-violet have been attributed by Schniederjost to the neutral atom of oxygen, but their relation to established series has not been traced. In an investigation of the ultra-violet line spectrum of chlorine [see Abstract 1855 (1923)] a number of well-defined bands were observed in the condensed discharge through a chlorine tube known to contain carbon, hydrogen, and oxygen as impurities. A close agreement of wave-length was found between the heads of these bands and some of Schniederjost's O.I lines. Only one line was detectedi n an attempt to photograph the oxygen spectrum in this region. Tables of wave-lengths are given from which it is seen that of Schniederjost's twenty-five O.I observations, twenty-one are good measures of Deslandres' carbon band-heads, one is a genuine oxygen line, while the other three are probably lines, but this is not yet proved. F. S.

1179. *A Method for the Preparation of the Double Fluorides of the Metals of the Platinum Group and the Absorption Spectra of the Halogeno Platinates.* **H. I. Schlesinger** and **M. W. Tapley.** (Am. Chem. Soc., J. 46. pp. 276–287, Feb., 1924.)—Potassium fluoroplatinate and potassium and lead fluoro-iridates have been obtained; absorption spectra of all of the halogeno platinates have been photographed. A study of the absorption spectra of potassium iodoplatinate in solutions of fluorides, chlorides, and bromides respectively, has demonstrated that the formation of the complex salts from one another is a reversible reaction, and that their relative stabilities can be determined by a spectroscopic method. W. V. M.

1180. *Theory of Multiplets and their Zeeman Effect.* **A. Sommerfeld.** (Ann. d. Physik, 73. 3–4. pp. 209–227, Jan., 1924.)—A continuation of theory previously developed [see Abstract 1394 (1923)], but modified to take account of recent work. It is now shown that the inner quantum number (j) is of the form $(u + \frac{1}{2})$ for even terms (doublets, quartets, etc.) and a whole number for odd terms (singlets, triplets, etc.). The same holds for the inner quantum number (j_s) of the s-terms; while the excitation quantum number (j_a) is a whole number and equal to $k-1$. Landé's formula for the anomalous Zeeman effect entails as its simplest consequence the "magneto-optic anomaly" that the magnetic moment of the atom for maximum value of j is equal to $2j_s + j_a$. The "magneto-mechanic anomaly" of Einstein and de Haas appears as a special case. The alternation law stated spectroscopically is that odd and even terms alternate in the periodic system, the maximum term-multiplicity being greater than the maximum valency by unity; while magnetically, taking the s-state of the atom as basis, it is that the number of magnetons measured in the units of Bohr's theory alternates from odd to even in the periodic system. F. S.

1181. *Soft X-Rays from Carbon.* **P. I. Lukirsky.** (Phil. Mag. 47. pp. 466–470, Feb., 1924.)—The filling of the gap between short ultra-violet and soft X-rays presents some interest in addition to the effect of obtaining a continuous scale of electromagnetic waves. The determination of the characteristic wave-lengths of the lightest elements is of great importance in the question of atomic structure, for the laws of atomic dynamics must take a particularly simple form with respect to the light elements containing a relatively small number of electrons. In carbon, which is the object of this investigation, each atom contains but six electrons, of which two form the K-group and four the L-group, coinciding with the optical one. The extreme ultra-violet spectrum of carbon has recently been investigated by Millikan, who succeeded by means of his diffraction grating in extending it to 202 Å. and later to 136 Å. On the other hand, soft X-rays have been measured by the crystal method up to wave-length of 12 Å. In the present experiments, the electrostatic method is employed, the condenser adopted being a spherical one. When the inner sphere is illuminated by the rays of frequency ν, it emits secondary electrons in different directions but with the same initial velocities v. In the radial electric field the electrons will move along any curve of second order and will reach the outer sphere as they move away from perihelion. When the retarding potential eV reaches the value nearly equal to their initial energy, only then will the electrons all at once be stopped and driven back to the inside sphere. Therefore, electrons of the same group, that is of the same initial velocity, will be stopped at the same time that the p.d. exceeds the critical value V, determined by the relation $Ve = mv^2/2$. This will correspond to a very marked drop of the secondary current on the curve current-potential. A diagram of the apparatus used is given. A bit of diamond is bombarded by a pencil of kathode rays from a Coolidge kathode. The primary p.d. varied from 250 to 750 volts and the primary current from 30 to 80 milliamps. X-rays from the diamond passed through a lead diaphragm, and further through a hole in the external sphere, falling on a thin zinc sphere connected with a string electrometer. The results obtained with a primary p.d. of 750 volts are represented diagrammatically, the stopping potential being taken as abscissa and the ratio secondary current/primary current as ordinate. This curve shows three distinct drops: (1) A small one for V = 20–26 volts; (2) another, also small, for V = 115–123 volts; and (3) a relatively strong drop for V = 248–252 volts. These numerical values may be interpreted as follows: Electrons with velocities corresponding to 243–252 volts are due to the K-line of carbon ejecting both outer and free electrons from zinc. The energy of one quantum of these rays is equivalent to 252 volts + the contact potential of zinc (1–2 volts), which corresponds to a wave-length $\lambda = 48 \cdot 9$ Å. This result is certainly correct with respect to the order of magnitude; if Kurth's numbers are taken for the limits of the K- and L-series of carbon (289 and 32·9 volts), then for the energy of the K-line we get $K = K_g - L_g = 289 - 32 \cdot 9 = 256$ volts. Richardson gives for $K_g = 286$ volts which makes $K = 253$ volts. The drop corresponding to 110–130 volts is due either to the ejection of electrons from the M-group of zinc by the K-line of carbon, or of the free and outer electrons by the M-line of the same metal, which must be present as a line of fluorescence. Both explanations are correct with respect to the order of magnitude. The small drop corresponding to 20–26 volts must be due to the ejection of electrons by extreme ultra-violet rays of carbon—the line 360 Å. found by Millikan corresponds to 27–28 volts. Although this method gives an accuracy to 1 per cent. only, it seems yet the only one which is used at present for the determination of wave-lengths in the interval considered. Further work is in progress. A. E. G.

1182. *X-Ray and Radium Protection Committee Revised Report No.* 1. (Brit. J. of Radiology, 20. pp. 27–34, Jan., 1924.).

1183. *Diffusion of X-Rays.* **M.** and **L. de Broglie.** (Comptes Rendus, 178. pp. 383–384, Jan. 21, 1924.)—Suggests that the magnetic deviation of secondary β-rays would afford a good method for verifying Compton and Debye's formulæ, for which Wilson's droplet method is not suitable. A. D.

1184. *Wave-Lengths of X-Rays under Diffusion, and Bragg's Law.* **E. Friedel** and **F. Wolfers.** (Comptes Rendus, 178. pp. 199–200, Jan. 7, 1924.)—Reaches conclusions adverse to Compton's results being explained by a change in the wave-length on diffusion. [See Abstract 545 (1924).] A. D.

1185. *Excitation, Reflection, and Utilisation in Crystal-Structure Analysis of Characteristic Secondary X-Rays.* **G. L. Clark.** (Am. Chem. Soc., J. 46. pp. 372–384, Feb., 1924.)—It is experimentally demonstrated that X-rays, characteristic of elements in a crystal, are excited in the crystal by a primary beam from a tube, and reflected by it both in accordance with the Bragg law and in an anomalous fashion. Details are given of a new ionisation spectrometer method of crystal analysis. A curve is plotted showing the characteristic K-series iodine spectrum through 5 orders reflected by the 100 planes of potassium iodide. Although the wave-lengths are identical with those of characteristic lines in spectra of target elements, the spectrum of the secondary rays differs very materially in relative intensity of lines, etc., from that of primary rays characteristic of the same element. The secondary iodine spectrum from a KI crystal enables a very accurate determination of the distance between planes containing iodine atoms, namely $3\cdot532 \times 10^{-8}$ cm. The interplanar distance in this crystal is $3\cdot737 \times 10^{-8}$ cm. A crystal of uranyl nitrate hexahydrate is found to reflect secondary L-series uranium rays, enabling the analysis of the spatial distribution of the uranium atoms in the lattice. The unit parallelopiped contains 4 molecules, is face centred, and has the parameters in three directions at right angles of $13\cdot01$, $11\cdot45$, and $7\cdot93 \times 10^{-8}$ cm. The excitation in and reflection by a crystal of X-rays characteristic of elements in it is not an ordinary resonance phenomenon, but is explained, together with all the peculiarities of the spectra, by the principle of the transfer to matter of radiation momenta in quanta.

Announcement is made of the discovery and analysis of tertiary X-rays produced by the impact upon atoms of secondary electrons which are in turn removed by impact from the K and L rings of atoms in the radiator by the primary beam of X-rays. A tertiary ray has a frequency which is the difference between that of a primary ray and of the critical absorption frequency characteristic of the element of the secondary radiator. A. B. W.

1186. *Scattering of X-Ray Quanta and the J Phenomena.* **A. H. Compton.** (Nature, 113. pp. 160–161, Feb. 2, 1924.)—Reasons and an apology are given for not referring to Barkla's earlier work on X-ray transformation [see Abstract 1877 (1923)]. Following this comes a discussion of the softening of the secondary X-rays from light substances in which the fundamental difference between Barkla's and the author's explanations is pointed out, reference being made to recent spectroscopic measurements of the X-rays scattered by graphite [see Abstract 282 (1924)]. Barkla's J transformation is stated to be less complete than the quantum theory now upheld. Barkla's attempts to disprove the existence of the recoil electrons resulting from Compton's theory of scattering are answered by the direct evidence for their existence afforded by Wilson's and Bothe's recent cloud-expansion photographs. In view of the small intensity and the longitudinal asymmetry of the scattered γ-rays and of the observed change of wave-length of scattered X-rays, the author fails to see how Thomson's classical theory of scattering is longer tenable, except as an approximation for great wave-lengths. On the other hand, the experiments of Barkla and others receive a satisfactory explanation. H. H. Ho.

1187. *Absorption of X-Rays by Iron, Cobalt, Nickel, and Copper.* **F. K. Richtmyer** and **F. W. Warburton.** (Phys. Rev. 22. pp. 539–545, Dec., 1923.)—The absorption coefficients for wave-lengths below the K absorption limit have been measured by the use of a large spectrometer with a selected calcite crystal giving a beam of exceptional purity. The chief difficulty was to secure uniform films of the pure metals. It is found that the sequence of values of the atomic coefficients is that of the atomic numbers, not that of atomic weights, and that the variation with atomic numbers is as the fourth power, as previously suggested, the relation $\mu_a = 22 \cdot 4 \times 10^{-27} N^4 \lambda^3 + \sigma_a$, holding within experimental error for all the ten elements for which the results have been obtained, from $N = 6$(C) to $N = 82$(Pb), except possibly iron, for which the experimental value is 3 per cent. too low. The values for carbon, lead, and tungsten are preliminary and are taken from data not yet published.

Method of producing a thin uniform sheet of cobalt suggested by Kayko. Chemically pure oxide was compressed to a thin plaque, then reduced in a furnace by an atmosphere of hydrogen. AUTHORS.

1188. *Asymmetry of Electron Emission from very Thin Metal Layers under the Influence of X-Rays.* **W. Seitz.** (Ann. d. Physik, 73. 3–4. pp. 182–189, Jan., 1924.)—Bragg and Madsen [see Abstract 1445 (1908)] and others concluded from experiments on the conductivity of the air behind and in front of metal plates subjected to X-rays that the electron emission was greater in the direction of the X-rays than in the opposite direction. These experiments were not, however, of a nature that made the interpretation of the results unambiguous. Experiments are now described free from the objections of the earlier ones. Thin plates of carbon and celluloid lightly platinised on one side so as to be, in effect, plates emitting electrons from one side only are placed in the X-ray stream first with the metal and then with the non-metal side facing the stream. From the ionisation effects produced in the surrounding chamber the number of electrons emitted is shown to be greater in the direction of the X-rays than in the opposite direction. The question arises as to whether this is true of the individual metal atom, or whether the asymmetry of emission from the plate is due to an asymmetry in the *velocities* of the electrons emitted by the atom in different directions rather than in the *numbers*, the differences in numbers emitted by the plate in different directions being due to different absorptions of the electrons of different velocities. From the results of experiments on layers of different thicknesses the author inclines to the latter view, though the figures for very thin layers make positive assertion difficult. G. A. S.

1189. *Diffraction of X-Rays in Liquids, Fluid Crystals, and Amorphous Solids.* **C. V. Raman** and **K. R. Ramanathan.** (Indian Assoc. for Cultivation of Science, Proc. 8. 2. pp. 127–162, 1923.)—The authors consider the explanation of the diffraction haloes observed when a point of monochromatic X-radiation passes through a film of liquid and is received on a photographic plate. Explanations previously suggested by Ehrenfest, Bouillon, and others are discussed and are shown to be inadequate.

The explanation of the phenomenon is shown to depend on the consideration that the positions of the molecules in liquids are not at random, but possess a certain degree of regularity which can be estimated thermodynamically from the compressibility of the fluid. The Smoluchowski-Einstein theory of light-scattering in fluids cannot be applied owing to the fact that it practically treats the fluid as a continuum, an assumption which is justifiable in the optical case but not in the X-ray problem where the wave-length is much smaller; it is essential here to take into account the discrete structure of the medium. For very small angles of scattering, however, the Einstein-Smoluchowski theory is applicable even in the X-ray problem and an explanation is readily forthcoming why liquids scatter very little at such angles. For larger angles of scattering the discrete structure of the medium is taken into account by analysing the distribution of matter in the fluid into a continuous "structural spectrum" which has its peak of intensity at a wave-length equal to the mean distance λ_0 between neighbouring molecules. The law of the structural spectrum is exponential and is given by

$$\mathrm{A\ exp.}\left\{-\frac{1}{16}\cdot\frac{\mathrm{N}}{\mathrm{RT}\beta}\cdot\lambda_0^3\left(1-\frac{\lambda_1^3}{\lambda_0}\right)^2\right\}d\lambda_1$$

The X-ray scattering in different directions is obtained very simply by combining the law of the spectrum with Bragg's formula $\lambda = 2\lambda_1 \sin \tfrac{1}{2}\theta$, and this gives a diffraction-halo with its maximum intensity in the directions for which $\lambda_1 = \lambda_0$. The curve of intensity of the scattering in different directions agrees well with the experimental results of Hewlett and the mean molecular distance λ_0 with the value deduced from kinetic theory.

A discussion of the case of liquid mixtures indicates that the X-ray diffraction-halo should be practically a superposition of the haloes due to the separate components, as Wyckoff has observed. X-ray diffraction haloes for anisotropic liquids and amorphous solids are also dealt with. A. B. W.

1190. *Identification of Lines of the N-Series.* **V. Dolejšek.** (Comptes Rendus, 178. pp. 384–386, Jan. 21, 1924.)—The identification of the N lines [see Abstract 1876 (1922)] is made uncertain not only by the lack of agreement and accuracy of values calculated from the different series of very short wave-length, but also by the fact that the majority of the lines can only be obtained from the two elements uranium and thorium. The latter fact becomes all the more important when it is observed that it becomes impossible therefore to use the Moseley diagram to determine the homologous lines. By comparison with certain lines in the bismuth spectrum it is shown to be probable that particular lines of the Ur and Th series most probably belong to the N-series. A. B. W.

1191. *Constitution of X-Ray Spectra of the L-Series of the Elements.* **H. Hirata.** (Roy. Soc., Proc. 105. pp. 40–60, Jan. 1, 1924.)—A mathematical paper based on the theories of Bohr and Sommerfeld. A short abstract is not possible. A. B. W.

1192. *Energy of the Characteristic K-Radiation from Certain Metals.* **E. C. Unnewehr.** (Phys. Rev. 22. pp. 529–538, Dec., 1923.)—*Energy of K-Radiation from Cr, Cu, Rh, and Ag, for Applied Voltages to 45 kv.*—Using a special Coolidge tube with a thin mica window, and a rotatable anti-kathode on which were mounted four metals, the intensities of the characteristic K X-rays from Cr (atomic number 24), Cu(29), Rh(45), and Ag(47), corrected for general radiation, for incomplete absorption in ionisation chamber, for incomplete reflection by crystal, and for absorption by mica window, were found to be approximately linear functions of the square of the applied voltage on the tube. The ratio of the intensities of the α and β radiations was constant for each metal and decreased regularly with increasing atomic number from 7·36 for Cr to 4·65 for Ag. The ratio of the α radiation to the general radiation also decreased, but more markedly, from 25 for Cr to 11·2 for Cu and 2·7 for Ag. Comparison with the theory of Bergen Davis shows good agreement for Ag and Rh, but not for Cr and Cu. This is probably due to the fact that the theory neglects the fluorescent re-emission of absorbed general radiations.

Absorption coefficient of Rh for its K-radiation was found to be 222 per cm. for $K\alpha$ and 178 per cm. for $K\beta$.

Absorption coefficients of mica for K-radiation from Cr, Cu, Rh, and Ag were found to be 227, 89·2, 7·7, and 5·1 per cm. for the $K\alpha$ radiation and 171, 66, 5·5, and 3·6 per cm. for the $K\beta$ radiations of the respective metals. AUTHOR.

1193. *N-Series of X-Ray Spectra.* **V. Dolejšek.** (Zeits. f. Physik, 21. 2. pp. 111–119, 1924.)—Theoretical considerations bearing on recent work of Bohr and Coster [see Abstract 1398 (1923)] and of E. Hjalmar [Abstract 1873 (1923)]. A short abstract is not possible. A. B. W.

RADIO-ACTIVITY.

1194. *The Genetic Connection between Thorium and Uranium.* **G. Kirsch.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 9. pp. 551–568, 1922.)—The existence of a radio-active ancestor of thorium, with atomic weight 232·1 + 4 = 236·1, or possibly 232 + 4 = 236, is assumed; in the latter case the thorium found in uranium minerals would be an isotope of ordinary thorium, the former having the atomic weight 232 and the latter the atomic weight 232·1; using Fajan's rule, which is subject to exceptions, for the connection between the probability of α-disintegration and the atomic weight, the half-life period of this hypothetical thorium uranium, symbol ThU, would be about 108 years. The author considers the possibility that, when the existing uranium ores were deposited, the uranium contained a considerable proportion of this substance, which has gradually disintegrated with the formation of

thorium, which is therefore more abundant in ancient ores than in those of more recent formation. The age of the ore can be determined, from the amount of RaG (radium lead) contained in it, and it becomes possible to work backwards and determine the half-life period of ThU from the thorium content; it is necessary to employ exclusively mineral in which the RaG content is accurately known, the amount of this substance and of ordinary lead being calculated from the atomic weight of the lead mixture; in some cases thorium lead may be present, which complicates matters. By a comparison of the analysis of brögerite from Moss in Norway, and pitch blende from Morogoro in East Africa, the half-life period of ThU was found. The age of the first ore was found to be 895 × 10^6 years, and of the second 605 × 10^6 years; the ratio Th/U in the first is 0·102, and in the second 0·00405, and the ratio of these two numbers is 25·0; if x is the number of half-life periods between the formation of these two ores $2^x = 25{\cdot}0$ or $x = 4{\cdot}64$; the actual time is 290 × 10^6 years, so that x, the half-life period is 63 × 10^6 years. Numerous other analyses are considered in the original paper.
H. N. A.

1195. *Dependence of Rubidium Radiation on Temperature.* **S. Geiger.** (Akad. Wiss. Wien, Ber. 132. 2a. No. 3–4. pp. 69–80, 1923.)—The researches on the radio-activity of the elements have shown that except in the region of the atoms numbered 81 to 92 only potassium and rubidium are undoubtedly active [see Abstract 1306 (1919)]. The ionisation current produced by the rubidium radiation has now been measured at 20° to 22° C. and − 165° to − 190° C., and is found to be constant within a probable error of 3 to 4 %. The rubidium radiation is therefore considered as independent of temperature within the given range of temperatures and it behaves exactly as the specific radiation of radio-active substances.
A. E. G.

1196. *Detection of Injected Polonium in Animal Organs.* **(Mrs.) J. S. Lattès** and **A. Lacassagne.** (Comptes Rendus, 178. pp. 630–632, Feb. 11, 1924.)—The organ is weighed and treated with nascent chlorine by gradual addition of $KClO_3$ and concentrated HCl; the action is energetic, and started in the cold is continued over a water bath out of doors; a clear homogeneous liquid is obtained; an excess of HCl is added, and a sheet of pure silver is boiled in the liquid for twenty minutes, the polonium being deposited upon it. The α-radiation from the two faces is measured in an ionisation chamber; this gives the activity contained in the original solution, with a small percentage error. When the residual solution is evaporated to dryness the activity in a large number of the cases examined was negligible compared with that on the silver plate. In measuring the total activity by adding the activities due to the two sides of the plate that of the edges is taken into account twice over, which gives an error in the opposite direction to that due to the activity in the dry residue; but both these errors are small, and their difference can be neglected. Fat in the organs is not destroyed by the Cl, but it was found to be quite inactive. Quantities of the order of 10^{-8} e.s.u. per gramme of organ can be determined by this method.
H. N. A.

1197. *Particles of Long Range Emitted from Active Deposits of Radium, Thorium, and Actinium.* **L. F. Bates** and **J. S. Rogers.** (Roy. Soc., Proc. 105. pp. 97–116, Jan. 1, 1924.)—An examination of the long-range particles emitted by the active deposits of radium, thorium, and actinium has been made by the scintillation method, advantage being taken of the recent improvements in the microscopes used for observing scintillations [see Abstract 1445 (1921)] Rutherford and Chadwick. In the case of radium active deposit, in addition to the particles of range 9·3 cm. previously found by Rutherford, particles of ranges 11·2 and 13·3 cm. have been discovered. The numbers of these three sets of particles are comparatively small; for every 10^7 α-ray emitted by radium C it has been found that there are present 380, 125, and 64 of these particles respectively.

In addition to the particles of range 11·5 cm. discovered by Rutherford and Wood [see Abstracts 689 (1916) and 1277 (1921)], it has been found that thorium active deposit also emits particles of ranges 15·0 cm. and 18·4 cm., the relative numbers of the 8·6, 11·5, 15·0, and 18·4 cm. particles being 10^6, 220, 47, and 55 respectively. Actinium active deposit has been found to emit particles of range 6·49 cm. previously recorded by Marsden and Perkins [see Abstract 1429 (1914)], to the extent of 0·322% of the total number of α-rays emitted by actinium C. Indications of the presence of particles of range greater than 6·5 cm. have been found, but it has been impossible to establish them, as the sources of actinium C used were not sufficiently intense. The bearing of these long-range particles on the modes of representation of the transformation of the C products of the radio-active substances has been discussed, and it is shown that these schemes must be regarded as incomplete. In particular, for the atoms of RaC and ThC, explanation must be found for the presence of four particles of different ranges. A. B. W.

1198. *Preparation of Radium C.* **H. Pettersson.** (Akad. Wiss. Wien, Ber. 132. 2a. No. 1–2. pp. 55–57, 1923.)—In preparing plates activated with radium C, by placing them in radon and connecting them to a negative potential of a few hundred volts, it has been found that the amount obtained was not very large, some 150 millicuries of emanation giving not more than 18 millicuries on the plate. A method is described in which the emanation is condensed by cold on the surface of an invar disc, fixed on the top of a short rod of invar steel, which is turned down to form a conical plug, closing the lower end of the glass tube containing the emanation. The lower part of the steel rod dips into liquid air, and a strong bluish light shows that the emanation condenses on the upper surface of the disc. A metal cover can be lowered on to the disc after condensation, and increases the yield of radium C; this cover consists of a metal ring, carrying a thin sheet of aluminium, thick enough to prevent the passage of the recoil atoms, but thin enough to allow the α-particles to pass without much hindrance. In the first experiment 350 millicuries of radon gave 60 millicuries of radium C on the disc, and 81 on the cover, measured 45 minutes after activation, so that the original amount of RaC was about 200 millicuries, not counting about 20 millicuries lost in washing with alcohol. H. N. A.

1199. *A Radium Balance.* **L. H. Clark.** (Journ. Sci. Instruments, 1. pp. 137–141, Feb., 1924.)—In radium therapy the economic use of metal tubes containing a radium salt necessitates frequent measurement of the contents of the tubes to detect and thus prohibit radium losses, which are, of course, liable to occur. The method of measurement must be rapid and entail little manipulative skill, if determinations are to be made as frequently as is desirable. For this purpose, therefore, a balance method is indicated and the instrument here described works upon this principle, which is identical with that of the X-ray balance [see Abstract 690 (1923)]. Two insulated chambers are maintained at a constant difference of potential by connecting them to the leads of a direct voltage supply. An insulated electrode entering both chambers makes electrical communication between them. The chambers are exposed simultaneously, one to the γ-radiation from the radium tube under test, the other to the α-radiation from a very small mass of radium. The two consequent ionisation currents cause the potential of the insulated electrode to rise to a steady value, when a balance is set up. The potential of the electrode is indicated by attaching to it a gold leaf. A mid-section diagram, to scale, of a radium balance suitable for measuring tubes containing up to 120 mg. of radium bromide is given. A balance ionisation method for measuring the β- and γ-ray activity of radium preparations has also recently been described by R. M. Sievert. A. E. G.

1200. *Capture and Loss of Electrons by Swift Nuclei.* **R. H. Fowler.** (Phil. Mag. 47. pp. 416–430, Feb., 1924.)—The equilibrium ratio of the concentrations of He^{++} and He^{+} in a beam of α-particles of given velocity is discussed in the light of Rutherford's experiments. It is shown that the equilibrium is probably of the nature of a thermodynamic equilibrium corresponding to an electron density equal to that of the lightly bound electrons in the interior of an atom (perhaps 2×10^{24} per c.c.) and a temperature equal to that at which electrons have on the average the velocity of the α-particle (5,800,000° C. for the initial velocity of α-particles from RaC). The mechanism of capture and loss is probably a collision mechanism (non-radiative). Loss corresponds to ionisation by electronic impact—capture to the strict reverse of this, a three-body collision. The calculated equilibrium ratios agree roughly with Rutherford's results. A. A. D.

1201. *Radio-Activity of Plants.* **A. Nodon.** Note by D. Berthelot. (Comptes Rendus, 178. pp. 486–487, Jan. 28, 1924.)—The author claims to have discovered that living organisms possess radio-activity, which seems to be a function of the degree of vitality, no appreciable radio-activity being shown by dead plants or animals. The pistils and stamens of plants give a greater effect than the leaves, and four or five times as great as uranium; in some insects it is greater than that of the radium employed in the experiments. The effect was greater in sunshine than in a closed room, and varied with the solar activity in the same way as the author has found for radium. In his note on the above **D. Berthelot** states that he obtained similar results in 1909 and 1910, but that further investigation showed that the real cause was humidity; the results were regarded as negative and were not published. H. N. A.

1202. *Experiments on the Artificial Disintegration of Atoms.* **G. Kirsch and H. Pettersson.** (Phil. Mag. 47. pp. 500–512, March, 1924.)—A method of obtaining strong preparations of radium C from radium emanation is described. The emanation is condensed on a metal disc cooled by liquid air and kept in the frozen condition for a couple of hours, so that the active deposit can accumulate; the disc is heated and the emanation pumped off. The life of radium C is, however, so short that for the disintegration experiments it was found better to employ emanation and disintegration products together, though this means that three different ranges of α-particle are involved. The emanation was introduced into five capillary tubes, 1 to 2 mm. thick and 20 mm. long, with walls of between 70 and 90μ thickness; a thin sheet of the substance to be examined lined half the length of the capillary, either as a tiny roll of metal foil pressing against the glass, or as a fine powder of oxide made to adhere to the glass by heating, stopping power about 2 cm. of air; both ends of the capillary were sealed off, and observations were made of the scintillations on a zinc-sulphide screen, using a suitable microscope. The whole of the radium C could be concentrated in one-half of the capillary by immersing it in liquid air, and it was found useful to investigate the action of the half of the capillary in which the substance to be examined was absent, as well as the other half; the number of long-range particles thus found was about one-tenth of that due to aluminium in the other half of the capillary; these are no doubt expelled from sodium in the glass, which thus proves to be not very suitable for the purpose. Capillaries of quartz were tried with a number of substances, with uncertain results, except that it was shown that the silicon of the quartz sent out H particles with maximal range at about 12 cm. of air. Experiments were also made in which the emanation was confined in a narrow trough in a sheet of brass covered with a strip of copper foil about 11μ thick; whether any H particles of range exceeding 8 cm. of air are expelled from copper or not must be left an open question, there are certainly many more expelled from troughs containing certain substances than from empty ones, and this is regarded as proving that the atoms of these substances are disintegrated. The range of the H particles from lithium was found to be 10 cm., beryllium 18 cm., magnesium 13 cm., and silicon 12 cm; the evidence in the case of lithium is less conclusive than for the others.

H. N. A.

1203. *Number of α-Particles Emitted from Radium. Part I. Scintillation Method.* **H. Geiger** and **A. Werner.** (Zeits. f. Physik, 21. 3. pp. 187–203, 1924.)—Rutherford and Geiger [see Abstract 1627 (1908)], by an ionisation by collision method, recorded the α-particles emitted from a known quantity of radium. The number finally given was $3 \cdot 57 \times 10^{10}$ α-particles per gramme of radium per second. Ten years later Hess and Lawson [Akad Wiss., Wien Ber. 127. 2a. 405 (1918)] redetermined this constant and obtained a value $(3 \cdot 72 \pm 0 \cdot 02) \times 10^{10}$. On account of the fundamental importance of this radio-active constant, since it controls the life and heat emission of radium, the authors have undertaken a redetermination by more refined methods. In the first method employed by them, and now described, the α-particles are counted by a scintillation method, and a value $3 \cdot 40 \times 10^{10}$ *α-particles per gramme of Ra per second* obtained. Using this value and assuming Millikan's value for it, the half-value period of radium is given as 1730 years; the helium emission as 159 mm.^{3} per year per gramme of Ra in equilibrium with $\mathrm{Em} + \mathrm{A} + \mathrm{C}'$; the heat emission of Ra (free from its products of decay) $22 \cdot 25$ cals. per hour per gramme. It is also calculated that the velocity of the α-particles from Ra is $1 \cdot 511 \times 10^{9}$ cm./sec. in good agreement with observation.

A. B. W.

1204. *The Absolute Energies of the Groups in Magnetic β-Ray Spectra.* **C. D. Ellis** and **H. W. B. Skinner.** (Roy. Soc., Proc. 105. pp. 60–69, Jan. 1, 1924.)—Describes experiments to determine with great accuracy the energies of certain prominent β-rays of radium B; the most accurate previous results were obtained by Rutherford and Robinson [Abstract 251 (1914)]; the measurements are of importance in connection with the theory that the β-rays are produced by definite γ-rays from the nucleus. The β-ray lines were photographed by the usual focusing method, the magnetic field being measured by a ballistic method in terms of the area turns of a search coil, which was rotated in the field through 180°, and a mutual inductance. Details are given of the accuracy obtained in the various measurements involved, and it is concluded that the actual effective field could be measured to an accuracy of 1 in 1000. The final error in determining ρ, the radius of the circle described by the β-rays, from measurements of the position of the source and of the photographic trace, was certainly less than 1 in 1000. A table gives the values of $H\rho$ for six different β-rays, with the energies in volts calculated by the relativity formula from the rounded final values. The maximum deviation from the mean is less than 1 in 1000, and the figures are regarded as probably correct to 1 in 1000, and certainly to 1 in 500. The results are compared with $H\rho$ values obtained by Rutherford and Robinson and by Danysz.

H. N. A.

1205. *The Capture and Loss of Electrons by α-Particles.* **E. Rutherford.** (Phil. Mag. 47. pp. 277–303, Feb., 1924.)—In a recent paper Henderson [see Abstract 1154 (1923)] has described experiments on the capture and loss of electrons by α-particles. The photographic effect of a pencil of α-rays was examined by him in a magnetic field by the photographic method, using Schumann plates. For the success of these experiments it was found essential that the apparatus should be exhausted to the stage of a kathode-ray vacuum and failure of previous investigators to note the effects observed by Henderson is to be ascribed to the presence of residual gas in the path of the rays in their experiments. While it had always been supposed that the α-particle captured electrons near the end of its path, it had not been expected that the α-particle could capture an electron in the early part of its range. The present investigation seeks to verify Henderson's conclusion by the scintillation method, where the energy of the particles can be estimated by the brightness of the scintillations and their number determined by direct counting. Full experimental details are included. The results obtained were in general agreement with those of Henderson and could be readily interpreted on the view that the α-particle captures electrons in its passage through matter, but it was of importance to settle definitely whether the particles in the midway beam consist of singly charged helium atoms moving with the same velocity as the corresponding particles in the main beam. For this purpose, the deflection of the midway band was determined in an electrostatic as well as in a magnetic field. From the results it appeared certain that the particles in the midway band were singly charged atoms of helium, *i.e.* helium nuclei which have captured one electron. It is thus natural to suppose that the undeflected particles are neutral helium, atoms arising from the capture of two electrons by the α-particles. The mean free path was then determined for capture and loss, following which an investigation was made of capture and loss at low velocities. The cases of undeflected particles, singly charged particles from naked sources, and the effect of gas in the path of the α-particles were next considered. Following this in the paper comes a discussion of the number of interchanges and a comparison with positive rays. When an α-particle captures an electron, it presumably falls in the majority of cases into the same orbit round the helium nucleus which characterises an ionised helium atom. The ionisation potential under these conditions is believed to be 54 volts. When the α-particle with the attendant electron passes through the atoms of a gas in its path, it will not only ionise the gas, but will occasionally be itself ionised, *i.e.* will lose its attendant electron. The mean free path calculated on these assumptions is of about the magnitude observed experimentally. This agreement indicates that in most cases the electron captured by an α-particle falls rapidly into the lowest quantum orbit and does not appear to circulate in an orbit of high quantum number, *i.e.* of low ionisation potential, even for the short interval of time required to traverse the short distance corresponding to the mean free path for loss. A long discussion is given for the capture of an electron by a high-speed α-particle, but while the problem is found to be too involved and complicated to reduce to calculation a few estimates of the order of magnitude of the quantities concerned are given.

H. H. Ho.

1206. *A Reinvestigation of the β-Ray Spectrum of Radium B and Radium C.* **C. D. Ellis** and **H. W. B. Skinner.** (Roy. Soc., Proc. 105. pp. 165–184, Feb. 1, 1924.)—C. D. Ellis has already given an interpretation of the β-ray spectrum of radium B [Abstract 1596 (1923)] based on the original measurements of Rutherford and Robinson. The authors have recently determined the absolute values of the energies of some of the lines of the β-ray spectrum of radium B [Abstract 1204 (1924)] and they now give measurements, based on these values, for the whole spectrum of RaB, and part of that of RaC. All the fundamental points of the previous investigations have been strengthened. For both RaB and RaC the spectrum is divided into three groups of lines C, D, and E; RaB has six C lines, eight D lines, and seventeen E lines. Energy differences $E_7 - E_3 = 0{\cdot}746 \times 10^5$ volts, $E_{10} - E_6 = 0{\cdot}746 \times 10^5$, and $E_{13} - E_9 = 0{\cdot}741 \times 10^5$ are important. The proof that E_3, E_6, and E_9 have energies corresponding to the conversion of γ-rays in the K level of the atom has been given in a former paper by measurements of excited spectra, so it is concluded that E_7, E_{10}, and E_{13} originate in the same way in the L levels, and it is finally concluded that all originate in L_{III}, the absorption energies of Bohr and Coster leading to this result. In the accompanying table the first line gives the name of the observed β-ray, the second the layer in which it originates, and the third the name of the nuclear γ-ray which produces it, the letter γ being in practice prefixed to the E in this case.

E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17
K?	K?	K	K	K?	K	L_{III}	L_{III}	K	L_{III}	M*	L_{III}	L_{III}	M*	N*	K	K
E1	E2	E3	E4	E5	E6	E3	E4	E9	E6	E6	E12	E9	E9	E9	E16	E17

The sign * means that it is impossible to decide which M or N level is involved. The γ-rays, γE3, γE4, γE6, and γE9 produce the main emission, γE4 being considerably weaker than the other three; γE1, γE2, and

γE5 are regarded as doubtful γ-rays, being deduced from one β-ray line. In the C group of RaB the β-ray C1 is assumed to come from the L_I level, C2 from L_{II}, C3 from L_{III}, C4 from M_1, C5 from N_1, and C6 from O, all being due to a γ-ray with about $0{\cdot}536 \times 10^5$ volts energy. The corresponding wave-length is 230 XU, which agrees with the value of Rutherford and Andrade, 229 XU, using the crystal method. The E group β-rays are due to conversion of γ-rays in the RaB atom, atomic number 82; but the C group rays by conversion in an atom the atomic number of which is 83, corresponding to that of RaC. For the interpretation of the D group, in which difficulties occur, the original paper should be consulted. The interpretation of the RaC spectrum is also difficult; γ-rays γE3, energy $2{\cdot}72 \times 10^5$; γE5, $3{\cdot}29 \times 10^5$ and γE7, $3{\cdot}86 \times 10^5$ volts are assumed, with doubtful γ-rays γC1, γE1, γE2, γE4, and γE9. H. N. A.

1207. *The Interpretation of β-Ray Spectra.* **C. D. Ellis** and **H. W. B. Skinner.** (Roy. Soc., Proc. 105. pp. 185–198, Feb. 1, 1924.)—Discusses the results of the authors' re-examination of the β-ray spectra of RaB and RaC [see preceding abstract]. Another interpretation is mentioned for the production of the E group of β-rays, depending on the radiationless transitions of Rosseland, which were mentioned in the previous paper in connection with the D group. In any case it is assumed that the RaB nucleus starts its existence in one of a series of higher energy states. Suppose a strong coupling between the nucleus and the electronic system, then the whole atom may undergo a transition, the final state being the nuclear particle in a lower energy state, and one electron from the *external* electronic structure ejected; the energy of the electron will be the same as if a γ-ray had been emitted by the nucleus, and had ejected the electron; the latter is probably what happens with the main β-ray groups of RaB, since it seems that the nucleus is so distinct from the electronic system that the first phenomenon could not occur. The absorption of the γ-rays by the electrons to form β-rays is surprisingly large, it appears that at least one β-ray line electron is obtained for every ten quanta emitted, various assumptions made about the properties of radiation on which absorption depends, give values which are far too small; the best is a pure light dart hypothesis, and this gives a result fifteen times too small. The following energy levels are deduced for the RaB nucleus, the numbers being the energy differences in volts from the zero level A, 0; B, $0{\cdot}537 \times 10^5$; C, $0{\cdot}625 \times 10^5$; D, $2{\cdot}572 \times 10^5$; E, $2{\cdot}942 \times 10^5$; F, $4{\cdot}048 \times 10^5$; G, $5{\cdot}31 \times 10^5$; a diagram shows how the various known γ-rays are produced by drops from one energy level to another; this includes rays measured by Rutherford and Andrade using the crystal method; the evidence as a whole is strongly in favour of the fact that quantum dynamics apply to the nucleus; but the difficulties and uncertainties are emphasised. The fact that the E-group lines appear to be produced in an atom with atomic number 82, while for the C group the atomic number appears to be 83 is also mentioned. Here the exact sequence of events in the disintegration is of importance, the E group γ-rays may be emitted before and the C1 γ-ray after disintegration; alternative explanations are given. The RaC, E-group, γ-rays are very similar to the RaB, E, γ-rays; and a level diagram is given for the nucleus of this element very similar to that of RaB; the levels and energy differences in 10^5 volts are A, 0; B, $0{\cdot}59$; C, $0{\cdot}70$; D, $3{\cdot}07$; E, $3{\cdot}30$; F, $4{\cdot}45$. Recent papers by Meitner, and by Hahn and Meitner, on the β- and γ-rays of uranium X are criticised; as far as the authors can see, this substance is a normal β-ray body, emitting a soft γ-ray from the nucleus like RaD. Space is not available for mention of other interesting points in the paper. H. N. A.

1208. *Secondary β-Rays Produced by γ-Rays from Radium.* **A. Enderle.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 9. pp. 589–605, 1922.) —The paper gives the results of an investigation of the secondary β-rays produced when γ-rays are absorbed by lead, gold, silver, nickel, and iron. For varying hardness of the incident γ-rays the secondary β-rays have a corresponding initial velocity. Each type of secondary radiation has a definite asymmetry-coefficient (— ratio of incident to emergent radiation) which increases as the hardness of the type increases. In this respect lead is anomalous. Otherwise the asymmetry coefficient increases with atomic weight, the values converging towards unity. A. B. W.

1209. *The Determination of the Radium Content of Feebly Active Substances by the γ-Ray Method.* **P. Ludewig.** (Zeits. f. Physik, 20. 6. pp. 394–397, 1924.)—The tedious manipulation involved in the emanation method for the determination of the radium content of feebly active substances has led to the present attempt to utilise the γ-ray method for this purpose. Bothe's experimental installation is first briefly described [see Abstract 1062 (1915)], as also an amended procedure by Dorsey [see Abstract 171 (1923)], which latter, however, has proved not so sensitive as the former for the present purpose on account of the much greater capacity involved. The author now describes in detail an arrangement by which much improved sensitiveness has been attained. In it a Wulf radiator has been employed of very low capacity and in conjunction with a specially calibrated bifilar electrometer. Data are included in support of the degree of sensitiveness claimed. H. H. Ho.

1210. *Chemical Action of Penetrating Radiation from Radium. Part XV. The Reduction of Calcium Persulphate.* **A. Kailan.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 9. pp. 569–581, 1922.)—In previous papers [see Abstracts 398 (1922) and 102 (1924)] the author and S. C. Lind have dealt with the chemical effect of α- and β-radiations. In the present publication the effect of γ-radiation on H_2O_2 solution, solutions of potassium iodide, and on solutions of calcium persulphate. The chemical actions observed are ascribed to the secondary β-radiations set up by the passage of the γ-rays through the solutions. A. B. W.

1211. *Spectrometric Measurements of the Colour Effects Produced by β- and γ-Rays.* **Maria Bělař.** (Akad. Wiss. Wien, Ber. 132. 2a. No. 1–2. pp. 45–54, 1923.)—Quantitative measurements by spectrophotometric methods of the colouring of glasses, kunzite (Californian), fluorspar, and rock salt by β- and γ-rays from radium are described. The final steady condition of colouring depends on the intensity of radiation emitted. For fluorspar and rock salt the measurements indicate that the rate of colouring is given by the exponential relation $n = n_\infty (1 - e^{-\beta t})$, n and n_∞ being measures of the colour intensity after times t and ∞ respectively. A. B. W.

HEAT.

1212. *Experiments by Watson Relating to the Dilatation of Water under Constant High Pressure.* **L. Bochet.** (Comptes Rendus, 178. pp. 554–556, Feb. 4, 1924.)—Results obtained by Watson, published in the "Recueil de constantes" by Marie, are shown to be at variance with those of Amagat and of Davis, and are therefore considered to be unreliable. T. B.

1213. *An Iron-Mercury Calorimeter.* **F. H. Schofield.** (Journ. Sci. Instruments, 1. pp. 141–144, Feb., 1924.)—A calorimeter is described, specially suitable for measuring the specific heat of materials of low thermal conductivity which react with water. It consists essentially of an iron block with a hole for the reception of the specimen, and provided with a lid from which a flood of mercury can be released on to the hot specimen when dropped from a furnace into the hole. A rapid interchange of heat is thus secured between the specimen and the calorimeter block. E. G.

1214. *A Calorimeter for Heats of Mixing at Elevated Temperatures.* **B. H. Carroll** and **J. H. Mathews.** (Am. Chem. Soc., J. 46. pp. 30–36, Jan., 1924.)—Description of a calorimeter capable of measuring heats of mixing at temperatures up to the boiling-point of the mixture. Data are given for the heat of mixing of the following liquids: Carbon tetrachloride and ethyl acetate, benzene and ethyl alcohol, ether and acetone, chloroform and acetone, ethyl alcohol and water. E. G.

1215. *Apparatus for Maintaining a Series of Constant Temperatures.* **H. Cardot, H. Laugier,** and **R. Legendre.** (Comptes Rendus, 178. pp. 81–83, Jan. 2, 1924.)—A quadrangular block of high thermal conductivity has its two ends curved so as to be at right angles to the length. One end is placed in a bath maintained at a constant high temperature, *e.g.* a boiling liquid, or molten metal, the other in a low temperature bath. Aluminium is chosen because of its high thermal conductivity, high specific heat, lightness, cheapness, and facility for being moulded. Ten cavities, equally spaced, are made on the top surface of the bar, which is suitably lagged. In one of the models constructed, the cold source is at 15° C. and the warm source at 100° C. It has a series of 10 constant temperature enclosures from 28° to 18° in steps of 5° C. It is found that the temperatures are more constant than those of the usual form of thermostat, as temperature variations at either of the sources are dissipated gradually and do not affect appreciably any given point. Numerous uses of the apparatus are suggested. T. B.

1216. *Thermal Conductivity of Liquids under Pressure.* **P. W. Bridgman.** (Am. Acad., Proc. 59. pp. 141–169, Dec., 1923. Nat. Acad. Sci., Proc. 9. pp. 341–345, Oct., 1923.)—An apparatus is described for measuring the thermal conductivity of liquids both at atmospheric pressure and high pressures; the method uses the radial flow of heat across a thin layer of liquid contained between two concentric metal cylinders. The importance of eliminating the effect of radiation through the liquid from one wall to the other in all methods of measuring conductivity of liquids is emphasised. The method is applied to the measurement of fifteen liquids over a pressure range of 12,000 kg./cm.^{2} at 30° and 75°. At atmospheric pressure the thermal conductivity of all the liquids except water decreases with rising temperature. Under pressure the conductivity increases by an amount varying from 1·5 to 2·7 fold for the entire pressure range. The effect is greatest for the most compressible liquids, and is least for water. The effect is far from linear with pressure, but the initial rate of increase of conductivity with pressure is several fold greater than the rate at 12,000 kg. At pressures above roughly 3000 kg. the temperature coefficient reverses sign, so that all these liquids are more conducting at high pressure at the higher temperatures. A simple theoretical formula for thermal conductivity of liquids has been obtained, in which the difference of temperature energy in a liquid in which there is a temperature gradient is represented as travelling through the liquid with the velocity of sound. E. G.

1217. *Wall Insulation.* **E. Griffiths.** (Nature, 113. pp. 240–242, Feb. 16, 1924.)—A scientific study of wall insulation involves determination, first, of heat conductivities of poor conductors, and, second, of the factors on which heat transmission from a wall surface to air depends. A method of determining such heat conductivities is described. [For results see Abstract 1172 (1923).]

In the case of a vertical wall at uniform termperature the rate of heat loss by air convection per sq. cm. is found by experiment to be greatest at the bottom of the wall. With increasing height the rate decreases to a minimum, as at higher levels the air coming in contact with the surface is already warmed. At greater heights still it increases slightly, presumably owing to turbulence, and then becomes constant.

Using a long electrically heated cylinder of variable height, the heat loss is measured for various steady temperatures and different heights. For each height a relation $H \propto \theta^n$ is found, H being the heat loss by convection per unit area and θ the excess temperature. A study of the values of n shows that height and temperature excess cannot be treated as separate factors. From theory it is shown that the equation for similar bodies should be of the form $H = \frac{\theta}{l} f(\theta l^3)$ where l represents the linear dimension. The experimental values fit in with this, and for large values of l the equation $\frac{Hl}{\theta} = (\theta l^3)^{1/3}$, *i.e.* $H \propto \theta^{4/3}$ represents the facts. G. A. S.

1218. *The Miscibility of Substances above the Critical Temperature.* **T. des Coudres.** (Ann. d. Physik, 73. 3–4. pp. 289–290, Jan., 1924).—The author employed an apparatus described by him in Ber. Sächs. Ges. d. Wissensch. 62. p. 296, 1910, in which pressures up to 500 atmospheres could be applied at 500° C. The earlier experiments had suggested the existence of a state of heterogeneous equilibrium above the critical temperature, without providing complete proof. In the present paper, experiments with air-water, water-benzene, and other mixtures are described, but no discussion of the theoretical meaning of the results is attempted. E. G.

1219. *Specific Heat and Heat of Mixture in the Neighbourhood of the Critical State of Miscibility.* **N. Perrakis.** (Comptes Rendus, 178. pp. 83–86, Jan. 2, 1924.)—Previous work on the crystallisation of certain binary mixtures [Abstract 2025 (1923)] led the author to conclude that a freezing-point curve with a large section nearly rectilinear indicated a state approaching non-miscibility. Curves of a similar nature are given in the present paper connecting other physical properties of binary mixtures, namely (1) differences between experimental and calculated molecular capacities for heat, and (2) heats of mixture, with the molecular concentrations. The binary systems studied are phenyl oxide–ethyl alcohol, benzene–ethyl alcohol, benzene–butyl alcohol (normal), and o-cresol–ethyl alcohol. As judged from the comparative lengths of the rectilinear portions of the curves, the degree of miscibility increases progressively from the first of these systems (phenyl-oxide-ethyl alcohol) to the last (o-cresol–ethyl alcohol). T. B.

1220. *The Difference of the Specific Heats, at Constant Volume, of a Liquid and its Vapour.* **A. Brandt.** (Ann. d. Physik, 73. 5–6. pp. 412–414, Feb., 1924.)—It is known that the difference of the specific heats at constant volume of a liquid and its vapour, at the same temperature is given by $C_v^f - C_v^d = r/T - dr/dT - AT[(\partial p/\partial t)^f d\sigma/dt - (\partial p/\partial t)^d ds/dt]$. Here f and d stand for liquid and vapour respectively, r is the latent heat of vaporisation, σ and S the specific volumes of liquid and vapour. The equation was given in 1897 by M. Planck, and later (1906) by E. H. Amagat [Abstract 1257 (1906)]. Values from Planck and Amagat corresponding to the right-hand side of the equation for CO_2 are given in tables. It is thus shown that at temperatures − 5°, + 10°, and + 25° C., $C_v^f - C_v^d = 0$. A similar result is also given by other so-called normal substances like pentane and isopentane. It must not be assumed, however, from the equality of C_v^f and C_v^d that the specific heat is independent of the volume, or that $(\partial c_v/dv)_t = 0$. This is proved by the direct measurements of Joly and others in the case of CO_2, and by A. J. Swart for dissociating gases. The approximate equality of C_v^f and C_v^d for normal substances can be explained as follows: The specific heat at constant volume consists of two quantities; (*a*) The constant specific heat c; (*b*) the varying quantity of heat which on raising the temperature 1° C. is used up in dissociation. If u_v is the molecular heat of dissociation, m the molecular weight, and if in 1 kg. of the substance x kgs. are already dissociated, then $C_v = C + (u_v/m)(\partial x/\partial t)_v$. For the equality of C_v^f and C_v^d it is only necessary that at the same temperatures $(\partial x/\partial t)_v^f$ and $(\partial x/\partial t)_v^d$ should be equal; that is, that on heating the same weight of liquid and of vapour at constant volume, the same number of associated molecules should be dissociated into single molecules. For substances not normal, this is not the case. For example, in the case of water at 100° C., $C_v^f - C_v^d$ is equal to about 0·5 cal. T. B.

1221. *The Ratio of the Specific Heats of Nitrogen and of Oxygen.* **J. R. Partington** and **A. B. Howe.** (Roy. Soc., Proc. 105. pp. 225–243, Feb. 1, 1924.)—The authors describe an investigation of the ratio of the specific heats (γ) of nitrogen and oxygen. The method was substantially the same as that described in Abstracts 691 (1914), 348 (1922), and consists in measuring the fall in temperature which occurs when a large volume of the gas is allowed to expand adiabatically. The authors critically review previous investigations and also draw attention to an arithmetical error in the earlier paper by Partington.

A summary of the data obtained by various investigators is given in the tables below :

RESULTS WITH NITROGEN.

Observer.	γ.	c_p.	C_v.	Temp. °C.
Masson	1·415	—	—	—
Cazin	1·41 ± 0·02	—	—	—
Holborn and Austin ..	—	0·2319	—	20
Holborn and Fleming ..	—	0·2358	—	20
Pier	—	—	4·918	20
Scheel and Heuse	(1·399)	0·2492	(4·990)	20
Schweikert...........	(1·402)	—	—	0
Dixon, etc.	(1·405)	—	(4·921)	20
Schulze and Rathjen..	1·4120	—	—	—
Present research......	1·4045	(0·2470)	(4·929)	20

RESULTS WITH OXYGEN.

Observer.	γ.	c_p.	C_v.	Temp. °C.
Masson	1·415	—	—	—
Dulong	1·415	—	—	—
Regnault	—	0·2188	—	15–200
Cazin	1·41 ± 0·02	—	—	—
Lummer and Pringsheim	1·3970 ± 0·0004	—	—	—
Scheel and Heuse	(1·399)	0·2182	(4·989)	20
Holborn and Austin ..	—	0·2195	—	20
Schweikert	1·402	—	—	0
Present research.......	1·3946 ± 0·0002	(0·2204)	(5·056)	20

NOTE.—Calculated values are enclosed in brackets.

E. G.

1222. *Vapour Pressures of Lithium Chloride Solutions at 20° C.* **B. F. Lovelace, W. H. Bahlke, and J. C. W. Frazer.** (Am. Chem. Soc., J. 45. pp. 2930–2934, Dec., 1923.)—This paper is a continuation of a series of studies of the vapour pressures of aqueous solutions begun by Frazer and Lovelace using an accurate static method which depends upon the measurement of the difference in pressure between pure solvent and solution contained in bulbs immersed in the same accurately regulated water thermostat by means of a Rayleigh manometer. The error involved in measuring the pressure differences by this method is approximately 0·0006 mm. The measurements were made at 20° C. and in the concentration range from 0·1 to 1·0 m.

An improved method for removing air from the solutions before measuring has been devised. The observed vapour-pressure lowering has been compared with those calculated from freezing-point measurements. [See Abstract 630 (1916).]

E. G.

1223. *Vapour Pressure of Monatomic Elements.* **R. W. Millar.** (Am. Chem. Soc., J. 45. pp. 2323–2329, Oct., 1923.)—The differential equation $dp/dT = \Delta H/T\Delta V$, expresses the change of vapour pressure with the temperature in terms of the heat of vaporisation and the change of volume. Neglecting the volume of the condensed phase, and assuming $pV = RT$, where V is the molar volume of the gas, we have $d \log p/d \log T = \Delta H/RT = \Delta S/R$. Here ΔS is the entropy of vaporisation $= S_g - S_c$, where S_g is the entropy of the gas and S_c that of the condensed phase. Lewis's theory of ultimate rational units gives $S_g = R \log (T^{5/2} . w^{3/2}/p) - 2{\cdot}63$ where w is the molecular weight of the gas. Also $S_c = S_0 + \int_T^{T_0} C_p . d \log T$, C_p being the molar heat capacity at constant pressure. Now C_p can be expressed most simply as $C_p = \alpha + \beta \log T + \gamma (\log T)^2$. Omitting γ we obtain $S_c = S_0 + \alpha \log T + \beta (\log T)^2/2 - \alpha \log T_0 - \beta (\log T)^2/2$. Combining these equations we obtain a differential equation of the form $dy/dx + y = ax - bx^2 + K$, of which the solution is $y = (a + 2b)x - bx^2 + Ze^{-x} - a + 2b + K$, where Z is the constant of integration. Here y stands for p the vapour pressure, and x is log T. By use of the equation, and knowing the values of α, β, and the entropy S_0 at temperature T_0, and one vapour-pressure measurement, in the case of the condensed phase of any element which vaporises to a monatomic gas, the complete vapour-pressure curve for that phase over the temperature range for which α and β are valid may be calculated. Tables are given in which the calculated values for mercury, sodium, zinc, and hydrogen (the heat capacity of H gas below 60° A. being assumed that of a monatomic gas) have been compared with the observed values of various investigators. Fairly good agreement is obtained. T. B.

1224. *The Heat of Vaporisation and the Pressure of Saturated Vapour at very Low Temperatures.* **A. Brandt.** (Ann. d. Physik, 73. 5–6. pp. 406–408, Feb., 1924.)—The heat theorem of W. Nernst was criticised by E. Ariès [see Abstract 525 (1917)]. In this criticism, assuming Clapeyron's equation, $r/u = ATdp/dt$ where r is the latent heat of vaporisation, and assuming $pu = RT$ for a vapour at low temperatures, Ariès arrived at the conclusions that $r_0 = 0$ and $r_0M/2T = 1$ near the absolute zero of temperature. Hence in Nernst's equation, $\log p = - mr_0/2T + mc_p \log T/2 + \log R + m(k - c_p)/2$ he obtains $\log p = - 1 + mc_p \log T/2 + \log R + m (k - c_p)/2$. In deducing this equation, however, Ariès assumes that at low temperatures $dp/dt = p/T$. The present author shows, as follows, that this assumption is not justifiable. If $pu = RT$, where u and p are functions of T, then $d(pu)/dt = pdu/dt + udp/dt = R$. Hence $dp/dt = R/u - (p/u)(du/dt) = p/T - (p/u)(du/dt)$. The last term, however, cannot be assumed to be zero, as claimed in effect by Ariès, since du/dt approaches infinity as p/u becomes zero. From Clapeyron's equation, $r = ATudp/dt = ART - ATpdu/dt$, that is r consists of two quantities, (1) the heat $ART = Apu$, which is equivalent to the external work of evaporation, and vanishes when $T = 0$; (2) the heat $- ATpdu/dt$ which does not vanish at $T = 0$. This heat is the inner latent heat of vaporisation which is employed in overcoming the force of cohesion. This force exists between the molecules even at very low temperatures when on vaporisation an increase of volume takes place. T. B.

1225. *Relation between Vapour Pressure and Vapour Composition in Binary Mixtures of Volatile Liquids.* **W. K. Lewis** and **E. V. Murphree.** (Am. Chem. Soc., J. 46. pp. 1–7, Jan., 1924.)—A stepwise approximate integration is presented for the Duhem-Margules equation, which makes possible the calculation of the composition curve for the vapour over a liquid mixture from the isothermal total pressure curve. The calculated values in all cases cited lie within 2 % of the experimental ones. T. B.

1226. *The Heat Equilibrium between Cavity Radiation and Quantised Atoms.* **O. Halpern.** (Zeits. f. Physik, 21. 3. pp. 151–158, 1924.)—Einstein's famous treatment [Abstract 654 (1917)] of the equilibrium of the internal and translational energies of quantised atoms and full radiation led him to the consideration of the existence of emission and absorption of definitely directed energy quanta, but this has not been verified experimentally though there is evidence in favour. The author attempts to show that by the application of classical considerations a number of hitherto unexplained effects (alteration of frequency and dissymmetry of the intensity) may be explained, the paper consisting of an analysis of Einstein's considerations.

Thus Einstein uses the idea that the probability that an atom in state 1 in unit time will pass into state 2 may be written $A_1^2 + B_1^2\sigma(\nu, T)$, σ becoming infinite with T while A and B are independent of T; while using Wien's law it is found that $A_1^2/B_1^2 = \alpha\nu^3$ while $\epsilon_1 - \epsilon_2 = h\nu$ . . . (1). The author suggests that it is not certain that A_1^2 may be neglected with respect to $B_1^2\sigma$ at high temperatures.

The question of the relation between temperature and these transition coefficients is discussed, and a slightly different formulation given to equation (1). In directed emission it is shown that atomic recoil leads to the irreversibility of the process.

The Einstein equations are obtained in a similar form considering translational and internal energies. The difficulties at high temperatures remain, but the quantities S_1^2 and S_2^1, analogous to Einstein's A_1^2 and B_2^1, are now dependent upon temperature. The essential point is emphasised that neither a directed emission, nor a uniform spherical wave emission, is assumed, nor any special assumptions made concerning the nature of the elementary process. Exactitude of the equation (1) is only obtained in systems of reference in which the atom is at rest before and after the process. W. V. M.

1227. *Gas Dissociation and Free Path.* **E. Schrödinger.** (Phys. Zeits. 25. pp. 41–45, Jan. 15, 1924.)—In this paper a theory of gas dissociation is mathematically sketched which closely follows that of Scherrer [Gött. Nachr. 5. 8. July, 1916], but in which the free path is used as the characteristic length. This conception is claimed as of importance for the theory of electrons in metals. H. H. Ho.

1228. *Imperfect Gases.* **N. Carrara.** (N. Cimento, 26. pp. 157–166, Oct.–Nov.–Dec., 1923.)—Deduces a formula

$$C_p = C_v + R\left(1 + \frac{2a}{pv^2}\right) = \alpha + \beta\theta + R\left(1 + \frac{2a}{pv^2}\right).$$

A. D.

1229. *Verification of van der Waals' Equation Corrected for the Quasi-Contraction of the Molecules from the Isothermals for Hydrogen Determined by Kohnstamm and Walstra.* **E. A. Holm.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 17. No. 20. pp. 1–58, 1922–1923. In German.)—This is a long paper containing twenty tables of data and calculated results, together with graphs in which the author applies the same method which he used in the case of the isothermals for oxygen, nitrogen, and hydrogen determined by Amagat. The equation in which the constants are to be determined is

$$p = \frac{\mathrm{RT}}{v} \Big/ [1 - b/v + 3b^2/8v^2 - 0\cdot0369b^3/v^3] - a/v^2 \quad . \quad . \quad (1)$$

and the fitting of the equation to the isothermals was made by the method of least squares, using the expression

$$\Sigma\left[p - \frac{\mathrm{RT}}{v}\Big/(1 - b/v + 3b^2/8v^2 - 0\cdot0369b^3/v^3) + a/v^2\right]^2 \times 1/p^2 = \text{minimum} \quad . \quad (2)$$

in which it is assumed that the percentage difference between observed and calculated pressures when it is accidental does not depend on the pressure. The observations of Kohnstamm and Walstra were made at a temperature of 15·5° C. for pressures up to 2256 atm. and at 20° C. up to 2285 atm. Kohnstamm and Walstra used the method of "electrical contact" for determining the volume in conjunction with the weight of mercury run out of a piezometer between successive contacts. The pressure was measured by a sensitive pressure balance of Schaeffer and Budenberg. It is to be noted that the two authors, on account of inadequate experimental arrangements, were unable to introduce a definite quantity of hydrogen into their piezometer, and consequently that in addition to *a* and *b* of equation (1) R has also to be considered as an unknown constant. The author concludes that, as in Amagat's experiments on oxygen, nitrogen, and hydrogen, the constants *a* and *b* are approximately independent of temperature; that the initial volume for the isotherms is sufficiently small to neglect the "Schwarmbildung" of the molecules, and that the same will be true for the experiments of Kohnstamm and Walstra since the initial pressure in these experiments was not smaller than in Amagat's case. Finally, there must be errors in the correction terms for the molecular volume in the equation of state as given in (1), and that in consequence there must be serious defectiveness in the classical gas theory since the equation of state is deduced from it. The paper must be consulted for details of the calculations. T. B.

1230. *A Simple Derivation of van der Waals' Vapour-Pressure Equation, with a Note on Molecular Diameters.* **S. P. Owen.** (Univ. of Durham Phil. Soc., Proc. 6. 5. pp. 308–311, 1922–1923.)—The change of a liquid into its vapour is considered as a unimolecular heterogeneous reaction and van der Waals' vapour pressure equation thereby deduced from the kinetic theory. Since the forces acting on a molecule in the liquid are, on the average, directed towards the liquid along the normal to the surface, the assumption is made that only those molecules possessing a certain critical velocity normal to the surface are capable of escaping from the liquid, and a result obtained identical with that derived on thermodynamical grounds by van't Hoff showing that the present procedure may be applied to homogeneous gaseous and heterogeneous reactions, by associating chemical activity only with those molecules which have a certain definite kinetic energy. Since the kinetic energy necessary for a molecule to penetrate the surface of its liquid completely is used up in doing work against the forces of molecular attraction, it is assumed that when a molecule escapes it has associated with it a certain amount of potential energy which is equal to this work, the potential energy being manifested at the surface of separation in the form of surface tension. Taylor's paper on the coalescence of liquid spheres [see Abstract 1972 (1921)] has led the author to communicate the present point of view which has been held since 1917 but not published owing to difficulties involved in the conception. The results derived agree very closely with the published data as obtained by the usual methods. H. H. Ho.

1231. *The Relation between van der Waals' Equation and Trouton's Formula.* **A. Brandt.** (Ann. d. Physik, 73. 5-6. pp. 403–405, Feb., 1924.)—Van der Waals' equation gives $(p + a/v^2)(v - b) = HT/m$, where H is constant for all substances, and m is the molecular weight. If T_1 is the boiling-point of a liquid at pressure p_1, σ_1 and s_1 the specific volumes of liquid and saturated vapour, then, when p_1 is sufficiently small we obtain $(a/\sigma_1^2)(\sigma_1 - b) = HT_1/m$, and $p_1 s_1 = HT_1/m$. At the critical point $T_k = 8am/27bH$. From these equations we obtain $b/\sigma_1 = 0 \cdot 5 \pm \sqrt{0 \cdot 25 - 8T_1/27T_k}$, where only the positive sign is admissible.

The equations of Clapeyron and Clausius-Maxwell give for the latent heat of vaporisation (r_1) at temperature T_1, $r_1 = A\{p_1(s_1 - \sigma_1) + a/\sigma_1 - a/s_1\}$. If σ_1 is small compared to s_1 and a/s_1 small compared to a/σ_1, then from the equations above we get $r_1 = A\{HT_1/m + 27T_k Hb/m\sigma_1\}$. Putting $A = 1/427$, $H = 845 \cdot 2$ we obtain

$$r_1 m/T_1 = 2\{1 + (0 \cdot 5 + \sqrt{0 \cdot 25 + 8T_1/27T_k})/(8T_1/27T_k)\}.$$

This expression shows that Trouton's formula $(r_1 m/T_1 = \text{constant})$ can only be obtained when T_1/T_k is constant for different liquids, that is when T_1 and Tk are "corresponding temperatures." Guldberg has shown that approximately the critical temperature and the boiling-point at atmospheric pressure are corresponding temperatures and that $T_1/T_k = 0 \cdot 6$. Inserting this value in the equation above, we obtain $r_1 m/T_1 = 10 \cdot 8$, about half the value of the constant in Trouton's formula (20 to 22). Exact equality is, however, not to be expected as neither van der Waals' equation nor Trouton's formula can claim an exact representation of the properties of different substances. T. B.

1232. *Comment on the Communication of L. Bochet, entitled "van der Waals' Law of Corresponding States."* **D. Berthelot.** (Comptes Rendus, 178. pp. 677–682, Feb. 18, 1924.)—A survey of the literature bearing on the validity of the law of corresponding states, both from the theoretical and from the experimental point of view. It is shown from much careful and consistent work carried out during the past thirty years that the law of corresponding states proposed by van der Waals is by no means exact, and it is held that the attempt of L. Bochet to revive the question at the present day is quite unnecessary. [See next Abstract.] Reference is made to three other points which, like the critical point, give "reduced" forms of van der Waals' equation of remarkable simplicity; the reduced formulæ, it is stated, fit experimental facts well, and in one case exactly. T. B.

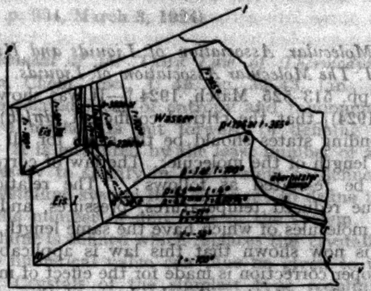
1233. *Van der Waals' Law of Corresponding States.* **L. Bochet.** (Comptes Rendus, 178. pp. 377–380, Jan. 21, 1924.)—When the units of pressure, volume, and temperature are so chosen as to be equal to the critical values of those variables, van der Waals' equation takes the well-known "reduced" form, which apparently contains nothing "specific" and is the same for all fluids. Van der Walls concluded from this, that provided the units are so chosen, the relation between the variables is effectively the same for all fluids. The validity of this conclusion is disputed. Consider the algebraic equation $\Sigma a\mathrm{V}^{\alpha}p^{\beta}\mathrm{T}^{\gamma} = 0$. Let this be transformed into a new system of units such that $\mathrm{V} = nu_{\mathrm{V}}$; $p = \epsilon u_p$; and $\mathrm{T} = mu_{\mathrm{T}}$, the magnitudes of the new units in terms of the old being u_{V}, u_p, and u_{T} respectively. The equation now becomes:

$$\Sigma a u_{\mathrm{V}}^{\alpha} u_p^{\beta} u_{\mathrm{T}}^{\gamma} n^{\alpha}\epsilon^{\beta}m^{\gamma} = 0, \quad \text{that is } \Sigma \mathrm{A} n^{\alpha}\epsilon^{\beta}m^{\gamma} = 0,$$

where the new constant $\mathrm{A} = a u_{\mathrm{V}}^{\alpha} u_p^{\beta} u_{\mathrm{T}}^{\gamma}$. This "reduced" equation no longer contains V, p, T, but the new abstract variables n, ϵ, m. Further consideration shows that to deduce the law of corresponding states for any series of fluids from van der Waals' reduced equation, it is necessary to establish (1) that each actually has a critical point, and (2) that the behaviour of each can be accurately represented by a relation involving three constants only. These conditions have never been fulfilled, so it is concluded that while the law of corresponding states may be true, it does not follow as a logical consequence on van der Waals' reduced formula. The experimental values are cited for carbon dioxide and water, and it is shown that there is considerable divergence in the behaviour of the two substances. T. B.

1234. *On a Proposed Empirical Equation of State for Fluids.* **S. Lees.** (Phil. Mag. 47. pp. 431–446, Feb., 1924.)—The general type of equation of state is assumed to be of the form $\{p + \phi(p, \mathrm{V}, \mathrm{T})\} . (\mathrm{V} - b) = \mathrm{RT}$, where p, V, R, and T have the usual significance, and ϕ is a function of which the form is to be determined. The equation is discussed mathematically with relation to the known properties of fluids, and an expression obtained for the function ϕ. The particular form of the equation so deduced, is $\{p + (ap^{1/3})/(\mathrm{TV}^{5/3})\} . (\mathrm{V} - b) = \mathrm{RT}$, or in terms of the reduced pressure, volume, and temperature, π, ν, and θ respectively $\{\pi + 4(\pi\nu)^{1/3}/(\theta\nu^2)\}(\nu - 1/4) = 15\theta/4$. Reference is made to the equations of van der Waals, Clausius, Dieterici, Porter [Abstract 711 (1923)], and others. It is claimed that the proposed equation agrees more closely on certain points with experimental facts. The chief properties of a fluid which follow from the equation are: (1) For large specific volumes the gas law holds; (2) for high pressures and low temperatures the volume tends towards that occupied in the liquid state; (3) critical phenomena are indicated; (4) near the critical point with increasing pressure, pV passes through a minimum value; (5) inversion in the porous-plug experiment is indicated; and (6) as the volume increases from a small value, the specific heat at constant volume increases, attains a maximum, and then decreases. T. B.

1235. *The Characteristic Surface (Thermodynamic Model) for Water.* **A. Brandt.** (Ann. d. Physik, 73. 5–6. pp. 409–411, Feb., 1924.)—The thermodynamic surface for water has a much more complicated appearance than that of normal substances. It is shown perspectively in the figure herewith, the axes being pressure (p), volume (v), and temperature (t). Here, *ednhl* is the "cylinder-surface" of vaporisation of water, *h* being the position of the critical point ($p = 196$ atmos., $t = 365°$ C.). The cylinder-surface *elrsm* corresponds to the evaporation of ice; *aedb* the melting of ice. The latter surface is covered in the figure by the thermodynamic surface of ice, since the specific volume of ice is greater than that of water. The three cylinder-surfaces cut each other in the straight line *del* corresponding to the triple point, at temperature 0·0074° C.



The diagram illustrates that water at atmospheric pressure has its greatest density at 4° C., but at higher pressures the greatest density corresponds to a lower temperature than this. At pressures above 2200 atmospheres, ordinary ice (named Ice I by Tammann) assumes an allotropic form (Ice III) which is denser than water at the same pressure and temperature. Thus the surfaces *abde*, *bgfc*, and *caki* intersect in the straight line *cba*. These three surfaces correspond respectively to the melting of Ice I, the melting of Ice III, and the change from Ice I to Ice III. Tammann has also discovered an Ice II. This, however, is omitted in the diagram for the sake of clearness. For the same reason the diagram is not drawn to scale. T. B.

1236. *Cohesion Pressure.* **A. Brandt.** (Ann. d. Physik, 73. 5–6. pp. 415–425, Feb., 1924.)—Substances obeying van der Waals' equation are supposed to be monomolecular in both the gaseous and the liquid states (*e.g.* CO_2), whilst substances departing from this equation are supposed to consist of associated molecules when liquid (*e.g.* H_2O). It is here suggested, however, that CO_2 shows evidence of progressive association, as the pressure is increased and the temperature lowered. The calculations are based on Amagat's experimental data. Van der Waals' equation is written in the form $10{,}333\left(p + \frac{a}{v^2}\right)(v - b) = \frac{845{\cdot}2T}{m}$, where m is the molecular weight. The constants a and b are selected on the basis of certain considerations and then m is evaluated for various temperatures and pressures. It is shown to vary from 100 to 44. This, in itself, however, is no conclusive proof of association, for, as the writer points out, the value of m may be kept constant at 44 by a different choice of values for a and b.

Amagat has suggested that the expression $T\left(\frac{\partial p}{\partial t}\right)_v - p$ represents the cohesion pressure in a gas. It is here suggested that on the basis of the association theory the correct expression is $T\left(\frac{\partial p}{\partial t}\right)_v - p - \frac{HT^2}{v-b}\frac{\partial n}{\partial t}$ where $n = \frac{1}{m}$. An explanation is then offered of the fact that under certain conditions of pressure the expression $T\left(\frac{\partial p}{\partial t}\right)_v - p$ is negative in the case of hydrogen. A. A. D.

1237. *The Molecular Association of Liquids and Highly Compressed Gases. Part III. The Molecular Association of Liquids.* **E. E. Walker.** (Phil. Mag. 47. pp. 513–525, March, 1924.)—It was shown in Part I [see Abstract 905 (1924)] that the critical coefficient $(d\pi/d\theta)_c$, which by the law of corresponding states should be the same for all substances, is a function of the length of the molecule. The law of corresponding states may therefore be re-stated as follows: "The relationships existing between the true reduced temperatures, pressures, and volumes of all substances, the molecules of which have the same length, are very nearly identical." It is now shown that this law is applicable to associated substances if proper correction is made for the effect of molecular association on the critical constants. On the basis of this modified law the association factors of a large number of substances at the boiling-point have been determined. T. B.

1238. *Radiometer Investigations. Part III. A Note on the Radiometer Theory of E. Einstein.* **W. Gerlach** and **E. Madelung.** (Zeits. f. Physik, 21. 4. pp. 254–257, 1924.)—The theory propounded by E. Einstein [see Abstract 1414 (1923)] leads to a law according to which the radiometer effect is proportional to the square of the thermal current. This result appears incompatible with the strict validity of the proportionality of a radiometer deflection with the absorbed radiant energy. Recent work by the authors [see Abstract 1566 (1923)] has confirmed the latter result within very wide limits, and the present paper describes further special experiments which establish the proportionality for all pressures including those at which the radiometer effect is of the dimensional order of the radiation pressure. Experimental details and data are included. H. H. Ho.

1239. *On the Function $\Delta\lambda = \phi(\lambda\theta)$ in the Theory of Radiation.* **C. Henry.** (Comptes Rendus, 178. pp. 558–561, Feb. 4, 1924.)—Owing to the discontinuities which are introduced in the theory of quanta, one cannot without precautions assimilate to a differential dx the very small variations of a physical quantity. Difficulties are thus encountered in Stefan's law $e = \int_0^\infty e_\lambda d\lambda = \sigma\theta^4$, and in Planck's equation

$$e_\lambda d\lambda = c d\lambda/[\lambda^5(e^{c/\lambda\theta} - 1)]$$

which are well interpreted by the perturbations due to a discontinuous quantity $\Delta\lambda$ which cannot from its nature be a differential. Experiment indicates that $c = h\mathrm{V}/k$ is a little smaller (1·42) for large values of $\lambda\theta$ than for small values (1·46), and one is led to seek in the function $\Delta\lambda = \phi(\lambda\theta)$ the reason of these discordances. This also follows from the fact that the temperature calculated from Stefan's law (which implies very large and very small values of λ) is greater than that calculated from Wien's law (based on mean values of λ). The same problem is encountered in the calculation of the quantities named by the author "instantaneous temperatures of establishment," τ. $\tau = n\epsilon_\lambda/(k \log p)$. These are produced when there is an emission of "grains of energy," ϵ_λ, p being the probability of this emission, owing to accidental variation of $E_\lambda \cdot d\lambda$.

Errata (*ibid.* p. 904, March 3, 1924). T. B.

1240. *A Statement of the Third Law of Thermodynamics.* **E. D. Eastman.** (Am. Chem. Soc., J. 46. pp. 39–43, Jan., 1924.)—In connection with the related ideas of entropy and randomness of the state of aggregation, a method is put forward of defining and measuring "randomness." It is measured by the least number of atomic positions which it is necessary to specify in any system to define completely its state. For a crystalline system it is sufficient to define the "unit cell," and to specify the number of unit cells in the system. In the case of glasses a unit volume is defined which replaces the crystalline "unit cell." An approximate numerical value can thus be given to the randomness of any system. Crystals of the simplest type require relatively few specifications, while glasses require very many. Complex crystals occupy an intermediate position. Hence all gradations must exist at the absolute zero, between the zero entropy of the simplest crystalline systems and the finite entropy of glasses. A particular form is assumed for the relation between randomness and entropy, from which it follows that the entropy of some crystals at the absolute zero may be large enough to be of practical importance in accurate determination of entropy from specific heats. The third law of thermodynamics is restated so as to conform to these conceptions. T. B.

1241. *Is the Notion of Entropy Particularly Abstract?* **L. Décombe.** (Comptes Rendus, 178. pp. 694–697, Feb. 18, 1924.)—The author points out that analogies to entropy may be constructed without explicit reference to probability, and gives details of one such instance. E. G.

SOUND.

1242. *The Physiological Measurement of Sound.* **A. Stefanini.** (N. Cimento, 26. pp. 137–142, Oct.–Nov.–Dec., 1923.)—Reference is made to the phonometer of Zwaardemaker with which he and Ohma have measured the energy of sonorous vibrations. The apparatus consists essentially of a small tube having the dimensions of the auditory canal, furnished with a wide collecting tube and forming a resonance chamber which opens into a chamber somewhat wider. On the axis of the resonator is suspended by a very fine thread of platinum of 5μ thickness a little mirror of 2 mm. diameter and thickness 60μ with its plane at 45° to the axis. If the distance of the little mirror from the free extremity of the small resonator is suitably chosen its deviations, which can be read on a distant scale, are proportional to the kinetic energy obtained from the sound waves. With this apparatus very feeble sounds can be measured. Zwaardemaker and Ohma have endeavoured with this apparatus to decide the controversy as to the method of measuring the intensity of sound, that is to decide whether it is proportional to the square or to the first power of the amplitude of vibration of the sonorous body. They have found that the deviations of the little mirror which are proportional to the energy of the sound wave are also proportional to the square of the amplitude of oscillation of the tuning-fork used. But the author points out that this does not decide the question of the proportionality of the intensity of sound to the first power of the amplitude which was sustained by him in 1889. It only shows that the mechanical energy of the vibrating body is proportional to the square of the amplitude of vibration. The physiological intensity of the sound is quite distinct from this, and the author maintains that it is proportional to the momentum and not to the kinetic energy and varies as the first power of the amplitude and not as the square. J. J. S.

1243. *Degradation of Acoustical Energy.* **M. D. Hart.** (Roy. Soc., Proc. 105. pp. 80–96, Jan. 1, 1924.)—In a homogeneous isotropic medium the intensity of sound will fall off with the distance from the source according to the inverse square law, unless there is some absorption in the medium. Stokes and Rayleigh have shown that absorption by the degradation of acoustical energy is to be expected on several counts, and will be most marked in the case of large amplitudes. As there is no method of measuring intensities direct, experiments in which pressure variations at different distances from a source are measured by a hot-wire microphone are carried out. Assuming that the same relation between intensity and pressure holds for finite as for indefinitely small amplitudes, the "degradation coefficient" can be calculated.

Using a siren with working pressure of only 4 to 5 lbs. per sq. in., 15·5 per cent. of the acoustic power at a distance of 40 cm. from the source was lost before 100 cm. was reached, and a very much greater fraction must have been lost between the source itself and 40 cm. For the efficient propagation of sound a high intensity at any point is thus to be avoided. Even if the above assumption as to the pressure-intensity relation is unjustified, the results enable a lower limit value to be assigned to pressure amplitudes above which deviations from the normal pressure-intensity relation are not negligible. G. A. S.

1244. *Physical Characteristics of Audition and Dynamical Analysis of External Ear.* **R. L. Wegel.** (Bell System Techn. J. 1. pp. 56–68, Nov., 1922.)—This paper discusses some of the characteristics of the ear which have become important in the design and development of telephone apparatus and circuits. The field of audition bounded by the curves of minimum and maximum loudness as functions of frequency, has been determined for a large number of ears, and the smaller included area most used in speech has been mapped. The nature of these fields in certain cases of abnormal hearing has also been determined and the conditions which must be observed in designing apparatus satisfactorily to relieve deafness are discussed.

The sensibility of the ear is given in terms of the root mean square pressure measured by a calibrated condenser transmitter. It is shown in the appendix that this pressure is not necessarily equal to that which, when applied to the ear drum, would just give rise to the sensation of sound. However, it seems to be the nearest approach to the value of this pressure which can be determined at present, and, as the dynamical properties of the ear become more fully known it is pointed out how the relation between these two pressures may be more accurately stated. E. H. B.

1245. *Binaural Location of Complex Sounds.* **R. V. L. Hartley and T. C. Fry.** (Bell System Techn. J. 1. pp. 33–42, Nov., 1922.)—Much has been written and experimentally investigated on the subject of the binaural location of pure tones, but the case of complex sounds has received little attention in recent literature. The attempt is here made to bring out the main features involved in extending the theory of the binaural location of pure tones to cover, qualitatively at least, the location of complex sounds. This discussion is theoretical but non-mathematical. It is assumed that the location of complex sounds involves three processes: (1) The resolution of the sound into its component pure tones, (2) the independent (usually subconscious) location of each component, and (3) the formation of a conscious judgment of the position of the source based on the locations of the source of these individual components. If these sources of components coincide, the accuracy of location and sense of certainty are increased. If they do not, confusion arises, subconscious corrections are called for, and the final result is likely to depend very considerably on the psychological processes and individual prejudices of the particular observer. E. H. B.

1246. *Wood Vanes in Phonograph Horns.* **W. R. Barss, J. A. Abbott, and H. M. Chatto.** (Mass. Inst. Technology, J. 3. 1. pp. 52–62, Jan., 1924.)—The intensities of sounds of frequencies varying from 100 to 1000/sec. emitted by a phonograph horn without vanes are compared with those emitted under similar conditions by a horn having several wood vanes running from front to back. Except between 600 and 800/sec. the latter horn gives the greater intensity; it also gives a quality more pleasing to the ear. G. A. S.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1247. *Electronic Conduction in Metals.* **A. Bramley.** (Phil. Mag. 46. pp. 1053–1073, Dec., 1923.)—The author's objective is the derivation of the law of force which is operative near the nucleus in the Rutherford atom and the explanation of the doublet structure assumed by J. J. Thomson in his electronic theory of solids, which has been gradually superseding the free electron theory, owing to the insurmountable difficulties encountered by the latter in phenomena observed by Kamerlingh Onnes at low temperatures. Starting with the potentials defined in the equations

$$\nabla^2\phi - 1/c^2 . \partial^2\phi d/\partial t^2 = -\rho \quad \text{and} \quad \nabla^2 U - 1/c^2 . \partial^2 U/\partial t^2 = -\rho V/c,$$

he first calculates the magnetic and electric forces at any point in space due to the revolution of an electron in a circular orbit with constant angular velocity about a positive nucleus. The field so obtained corresponds to that produced by the simplest Bohr atom—hydrogen—when the single electron is in the non-radiating state, moving in a quantum ring, the electric and magnetic intensities at any point being functions of period equal to that of the electron. A. Riemann time space is assumed and the space supposed to be calibrated, as suggested by Weyl, by a definite measuring rod placed at each point, and recalibrated by a new set of standards such that l', the length of the new standard relatively to the former one satisfies the equation $l' = \lambda l$ where $\lambda = \lambda(x_1, x_2, x_3, x_4)$. Then the metric will be characterised relatively to a system of reference by a quadratic differential form, $ds^2 = \Sigma g_{ij} dx^i dx^j$, and a linear one, $d\phi = \Sigma\psi_i dx^i$, provided λ be so chosen that $d\phi = 0$, which will make l independent of the path. The conditions for this are the vanishing of six equations of the type $\partial\psi_3/\partial x_2 - \partial\psi_2/\partial x_3 = 0$. If the ψ's were electromagnetic potentials, these would give precisely the three components of the electric and magnetic forces which are zero in this case. Natural phenomena being independent of the coordinate system, or of the standards of length, all quantities or relations representing these analytically must contain the functions g_{ij} and ψ_i in such a way that invariance holds, for any coordinate transformations, and for the substitutions which replace g_{ij} and ψ_2 by λg_{ij} and $\psi_2 - \partial \log \lambda/\partial x_2$. Given the g's and ψ's, the co-ordinate and calibration invariance determine all the physical properties of the manifold. The author assumes the latter such that the trajectories considered are geodesics in the manifold, as tacitly assumed by Einstein, and is really a device for integrating the equations. It is shown that $g_{ij} = 0$ or ρ for $i \neq j$ and $i = j$, respectively, so the manifold is Euclidean. From Hamilton's principle applied to the charge of coordinates he draws the conclusion [see L. P. Eisenhart, Nat. Acad. Sci. Proc. Jan., 1923] that the laws of perfect fluids, which follow from the invariance, must be valid in all Riemannian manifolds (*e.g.* the law of continuity holds good). This is the case also for the whole of the dynamics of material systems, and when there is calibration invariance also, the laws of the electromagnetic field are found to be consequences of the invariant nature of the equations. The form of the kinetic energy (so-called energy tensor) for an electron under the influence of a positive nucleus is then immediately derived. Schwarzschild's solution for a particle in the gravitational field of a spherical particle by simply substituting e for m. The author then uses Schwarzschild's line element to transform Einstein's equation so as to pass from discrete particles to a continuous medium and, utilising previous results of his own and of Eisenhart and Veblen, derives the conclusions that the inverse square law holds only in systems free from energy radiation, so that when present Maxwell's equations require modification, in accordance with Bohr's theory. In open orbits, *e.g.* an α-particle approaching an atomic nucleus, Rutherford's experiments show that the inverse square law cannot hold. The form of the author's differential equation accords with Rutherford's experiments making the electric intensity infinite in the region of the nucleus, and a change of sign of the intensity in the immediate vicinity of the singular shell accounts for all the negative charges in the universe not having been neutralised. The universe of the nucleus, received from within, would seem spatially infinite, the region beyond $r = 2e$ being shut off by a barrier of space and time. Taking an electron on the boundary of the region $r = 2e$, and letting it move under the action of the nucleus, it will fall towards the latter, coming to rest on the singular shell which it cannot pass, so that there is in the system a stable electric doublet composed of the nucleus and the electron, whose moment is $M = 10^{-22}$ electrostatic unit. This stable doublet is assumed by J. J. Thomson in his work on electronic conduction. The effect of the external field on the direction of the doublets gives qualitative results agreeing with experiment at all temperatures.

G. W. de T.

1248. *Equilibrium and Deformation of Conducting Systems Traversed by Currents and of Magnetic Bodies without Hysteresis.* **A. Liénard.** (Ann. de Physique, 20. pp. 249-360, Nov.-Dec., 1923.)—The present study is a continuation of previous investigations of the electromagnetic energy and thermodynamic potential of a system of currents in presence of magnetic substances void of hysteresis [see Abstract 1583 (1921)]. The work done is now calculated for a displacement with or without deformation of such a system. The classical electrodynamic hypotheses are utilised on the assumption of closed circuits and instantaneous propagation. Comparison of the results is made with those of electrostatics where it is shown that, notwithstanding the initial difference in the expression for the thermodynamic potential in the two cases, the results may be expressed in identical form. The Heaviside units are used, and vector notation employed, while in consequence Maxwell's "magnetic force" has been adopted rather than the usual conception of "field."

The paper, which is entirely mathematical, contains seven chapters dealing respectively with: (1) Thermodynamic potential of a system comprising conductors traversed by currents and near perfectly soft magnetic bodies. (2) Evaluation of work done. (3) Equilibrium of a magnetic body without hysteresis. (4) Determination of the resultant of forces and couples acting on a magnetic conducting system surrounded by a fluid medium which is magnetic, insulating, homogeneous, isotropic, and incompressible. (5) Study of the deformation of a magnetic wire wound in a coil. (6) Pressures in the interior of magnetic bodies void of hysteresis. (7) Comparison with electrostatics and applications of formulæ to certain electrostatic problems, *viz.* I. The attraction between conductors immersed in a dielectric medium which is homogeneous, isotropic, incompressible and at constant temperature. II. Comparison with Sacerdote's results upon electric deformations of dielectrics [Thesis and "Ann. Chimie et Physique," 1900, 7^e série, 20 pp. 289–377]. Seven appendices deal with particular problems of pure mathematics raised in the course of the investigation. H. H. Ho.

1249. *The Analogy between Electromagnetic and Influence Machines.* **F. Ollendorff.** (Elekt. Zeits. 45. pp. 210–213, March 13, 1924.)—In this paper the results of previous work by the author [see Abstract 126 (1924)] on influence machines are compared with analogous known data for electromagnetic machines, and a close relationship found to exist between the two groups of machines. In particular the characteristics of influence transformers, synchronous and commutator machines are discussed. H. H. Ho.

1250. *The Analytical Treatment of the Fundamental Problems of Electrostatics.* **K. Hillebrand.** (Phys. Zeits. 25. pp. 8–13, Jan. 1, 1924.)—The proposals of C. Neumann of the so termed element considerations and element potentials and their applications by him to plane curves, are now shown to afford, on rational application to three-dimensional space, the possibility of solving in a general manner the fundamental problems of electrostatics, *i.e.* the equilibrium distributions upon conductors of any given form. By this means the parameter representation of surfaces and the coordination of their points to spherical coordinates can be so chosen that magnitudes and relationships occur which admit of very simple geometrical treatment for the elucidation of physical significance. The paper is mathematical throughout. H. H. Ho.

1251. *The Absence of Ionisation by Electrons with Speeds Comparable with that of Light.* **W. F. G. Swann.** (Phil. Mag. 47. pp. 306–319, Feb., 1924. Paper read before the Am. Phys. Soc., 1922.)—The main interest of the problem here discussed lies in its relation to certain types of theories of the earth's electric charge, in which the replenishment of the charge lost by conduction through the atmosphere comes about in virtue of the agency of high-speed electrons shot into the earth from outside. These theories are briefly reviewed [see Abstract 230 (1920)], in all of such the following fundamental difficulty being inherent, *viz.* The maintenance of the earth's charge necessitates the assumption of an entry of electrons to about 1500 per sq. cm. per sec. Now, it is known that for electrons travelling with speeds 98 % of that of light, each one produces about 40 ions in each cm. of its path, so that, on this basis, a rate of production of about 60,000 ions per c.c. per sec. near the earth's surface should be expected, whereas actually ions are produced to only one ten-thousandth of this amount, and such ions as are produced may be satisfactorily accounted for by other causes. The present paper attempts to overcome this difficulty by discussing the mechanism of the ionisation in terms of classical dynamics. It is shown that there is mutual consistency between the phenomena in the statement that if corpuscles should enter the atmosphere from outside, in the equatorial plane, with energies sufficient to enable them to reach the earth's surface in spite of the earth's magnetic field, which would tend to return them to space, they would pass right through the atmosphere with but little absorption, and would fail to ionise the air through which they passed. An appendix deals with mathematical details under the headings: Concerning the form assumed by Sir J. J. Thomson's theory of ionisation when the speed of the corpuscles approximates to that of light; Regarding considerations arising from the finite size of the electron; Concerning the path of a corpuscle entering the atmosphere in the equatorial plane of the earth's magnetic field; Concerning conclusions to be drawn from M. Bohr's theory of the "Decrease of velocity of swiftly moving Electrified Particles in passing through matter." H. H. Ho.

1252. *Atmospheric Ionisation.* **A. Gockel.** (Phys. Zeits. 24. pp. 500–503, Dec. 1 and 15, 1923.)—A review of data relating to the electrical state of the atmosphere in relation to meteorological data leads the author to think it probable that cosmic radiation influences atmospheric ionisation. [Abstract 2373 (1923).] W. A. R.

1253. *Air-Earth Currents and Others.* **F. Sanford.** (Science, 59, pp. 194–196, Feb. 22, 1924.)—Replies to certain criticisms of an earlier paper [Abstract 1919 (1923)] made by L. A. Bauer, and proceeds to extend the argument to the diurnal variation of potential gradient, the annual variation alone having been considered in the first article. Then directs criticism at Bauer's work on vertical electric currents in the atmosphere, particularly the results given in the paper dealt with in Abstract 698 (1921). M. A. G.

DISCHARGE AND OSCILLATIONS.

1254. *The Connection between Neutralisation of Nuclei and Secondary Radiation with α-Rays and Canal Rays.* **E. Rüchardt.** (Ann. d. Physik, 73. 3–4. pp. 228–236, Jan., 1924.)—The author has recently published a detailed account of researches on the transformation of homogeneous H-atom canal rays [see Abstract 2474 (1923)]. He has also attempted a theoretical explanation of these phenomena [see Abstract 1924 (1923)] and the same question has been considered by Wentzel, who has arrived at similar conclusions. It is considered that further work is required on α-rays and canal rays. There appears to exist a parallelism between the transformation and the ionising tension. The transformation process $He_{+} \rightarrow He_{++}$ has not been observed in the region of the canal rays, while the processes $H \rightarrow H_{+}$ and $He \rightarrow He_{+}$ are quite normal up to small velocities. The ionising tension of He_{+} is nearly four times greater than that of H-atoms and nearly double that of neutral He-atoms. It can be assumed that in canal rays He_{++} is formed, but that with the small velocities the life-period of the α-particles is so small, the taking up of electrons follows so quickly, that the concentration of these particles is only very small. H_{+} ions and He_{+} ions also have, at proportionately small velocities, a not inconsiderable concentration, still this likewise diminishes with diminishing velocity. A. E. G.

1255. *The Kinetic Energy of Electrons Emitted from a Hot Tungsten Filament in an Atmosphere of (a) Argon, (b) Hydrogen.* **J. F. Congdon.** (Phil. Mag. 47. pp. 458–465, Feb., 1924.)—Recent experiments by Jones [see Abstract 1941 (1923)], Germer and Potter [see Abstract 315 (1924)] have shown conclusively that the electrons emitted from hot metals *in vacuo* possess kinetic energy in accordance with Maxwell's distribution law. This paper deals with experiments on the kinetic energy of the electrons emitted from a hot tungsten filament in (*a*) an atmosphere of argon, (*b*) hydrogen. The apparatus used was similar to that used by Potter (*loc. cit.*) and the method of measuring the kinetic energy of the electrons that employed by Jones (*loc. cit.*) in the latter part of his work. It was found that the average energy of the electrons emitted from a hot tungsten filament *in vacuo* is in close agreement with the requirements of Maxwell's distribution law. The presence of argon over a wide range of pressures has no effect on the measured average energy, but the presence of hydrogen, even at low pressures, appears to increase the measured average energy considerably, whilst maintaining the linear relation of the ($\log i/i_0$, V) curve. Hydrogen, therefore, has some property not possessed by argon.

H. H. Ho.

1256. *The Thermodynamics of Thermionic Emission.* **C. Davisson.** (Phil. Mag. 47. pp. 544–549, March, 1924.)—The usual procedure to avoid difficulties in applying the principles of thermodynamics to the thermionic properties of hot bodies is to assume that the temperature of the system is kept so low during the reversible changes that no very great number of electrons is present in the gaseous state. The intensities of the electric field approach zero as the space-charge is reduced, assuming the net charge of the system zero, and at sufficiently low temperatures the gaseous electrons will be almost uniformly distributed. It is assumed in the simple argument that all changes take place at temperatures for which the variations in electron density may be disregarded. With this limitation the problem becomes that of an ordinary saturated vapour, and the vapour pressure (molecular or electronic) is given by $p = \mathrm{AT}e^{\int \mathrm{W}d\mathrm{T}/k\mathrm{T}^2}$, where A is a constant, W the work required to transfer a single particle from the condensed to the gaseous state, and *k* is Boltzmann's gas constant. This result is combined in the thermionic problem with a theorem of the kinetic theory to give, $i = \mathrm{A'T}^{\frac{1}{2}}e^{\int \mathrm{W}d\mathrm{T}/k\mathrm{T}^2}$, as the relation between T and *i*, the current-density of emission. Strictly, the temperature restriction should be carried over into the argument, and, while there is not much question as to the correctness of the usual extrapolation to higher temperatures, the deduction is now presented in a form in which the temperature restriction is entirely avoided.

H. H. Ho.

1257. *Statistical Equilibrium with Special Reference to the Mechanism of Ionisation by Electronic Impacts.* **R. H. Fowler.** (Phil. Mag. 47. pp. 257–277, Feb., 1924.)—In a number of recent papers, the earliest by Klein and Rosseland [see Abstract 701 (1921)], it has been shown that the study of specific atomic processes of energy exchange in quite general terms, is likely to prove exceedingly fruitful. The theory of collisions of the first and second kind by the above authors is now discussed and further amplified. It is shown what type of relations can be strictly deduced in the case of atoms, with more than two stationary states, also how to formulate the theory when the atoms are no longer assumed to be of infinite mass. The same ideas are then extended to the mechanism of ionisation by collision. The reverse process is a three-body collision and the necessary frequency relation is determined. The theory and experimental results of ionisation by β-particles is next applied to deduce the form of the frequency function for one of these processes (ionisation) and the frequency function for the other is derived. Finally, the relative importance of collision and radiotive processes is formulated and discussed in a number of cases for gaseous assemblies. It is shown that either type may be dominant. H. H. Ho.

1258. *Photoelectric Action in Rock-Salt Crystals.* **J. Bingel.** (Zeits. f. Physik, 21. 4. pp. 229–241, 1924.)—" Photoelectric currents " in natural and artificially coloured rock salt were measured by Röntgen's method. There were thus made use of the same conditions under which were produced the simple phenomena of the photoelectric primary current in the case of the photoelectric conducting crystals of refractive index higher than 2. There was found: (1) Capacity of reproduction of the measurements even after weeks, (2) linear connection between current and potential, no sign of saturation even with field strengths of 50,000 volt/cm., (3) proportionality of the current to the light energy, (4) additive law with partial illumination. The observations leave it undecided whether actual photoelectric conduction or polarisation of the dielectric is concerned. A comparison of the results with the quantum equivalent law rather supports conduction. At least displacements over only molecular distances are excluded. A falling-off with time of the photoelectric currents is due to the establishment of an opposing field. This decrease was proved by Röntgen and a quantitative account is given of it by the author. J. J. S.

1259. *The Normal and Selective Photo-Effect of the Alkali Metals.* **K. Farwig.** (Zeits. f. Physik, 21. 1. pp. 38–45, 1924.)—An account is given of various measurements which confirm and extend the observations made by Pohl and Pringsheim in 1910 on the normal and selective photoeffects in the case of the metals potassium, sodium, and rubidium. The account given by Pohl and Pringsheim of the superposition of the two effects is shown to be correct. J. J. S.

1260. *Theory of Positive Ions and Electrons Emitted by Glowing Metals.* **M. v. Laue.** (Preuss. Akad. Wiss. Berlin, Ber. 32, pp. 334–348, 1923.)—This is a theoretical paper mainly of a mathematical nature. Goetz has recently published the results of some experiments on the behaviour of negative saturation currents at the melting point or other change points of conducting bodies. The theory underlying this is discussed. A. E. G.

1261. *The Theory of the Electronic Current by Impact Ionisation.* **L. Heis.** (Phys. Zeits. 25. pp. 25–41, Jan. 15, 1924.)—For discharges in dense gases, under which the potential difference of the electrodes amounts to a large multiple of the ionisation potential, Townsend's expression for the electronic current is in good agreement with observation [see Abstract 918 (1916)]. With the inert gases, however, a small but real deviation occurs [see Abstract 1440 (1923)]. When the electrode distance is comparable with the free path of an electron, and the potential difference with the electron is a multiple of the ionisation potential, then an electronic increase definitely ensues by collision in discontinuous manner. Under these circumstances the Townsend expression is no longer valid, and so is inapplicable for the quantitative examination of procedure in discharge tubes where less than 100 volts are used and in which the kathode fall can only amount to a small multiple of the ionisation potential. In the present paper Townsend's theory is extended to include this case and that of the inert gases. The basis of the theory is exhaustively discussed and a mathematical treatment included, satisfactory comparison being then made with the experimental data. In conclusion the author remarks that the theory of the electronic current is an essential basis for the theory of the discharge mechanism in gases. The structure of the electronic current also forms the skeleton for the spatial arrangement of the optical phenomena during gas discharges. It is, however, impossible to establish a satisfactory theory of the latter until the behaviour of ions can be quantitatively described in like manner to that for electrons. H. H. Ho.

1262. *A New Method of Determining Radiating and Ionising Potentials not Necessitating Low Pressures.* **W. J. Clark.** (Univ. of Durham Phil. Soc., Proc. 6. 5. pp. 312–322, 1922–1923.)—If the molecules of a gas are subject to bombardment by an electron stream, any encounters taking place do not involve interval molecular absorption of energy unless these electrons possess an amount of energy equal to or greater than $V_r e$, where e is the electronic charge and V_r the first radiating potential of the gas. In the latter case, such encounters result in energy transference sufficient to bring about displacement to less stable orbits, of valency electrons of the molecular systems affected, and hence diminution in velocity of the bombarding particles. The present investigation relates to the changes occurring both in the velocities of the electrons constituting a current passing through a gas, and of the value of this current under suitable conditions, in order to afford experimental evidence of the existence of radiating potentials. Details of apparatus are included for a modified procedure to that usually employed, certain advantages being claimed, *viz.* the pressure need only be of the order of 1 mm. with consequent reduction of the magnitude of disturbing effects due to impurities or mercury-vapour, and obviating the necessity of keeping a constant stream of gas at low pressure circulating through the experimental tube. The paper concludes with a description of experiments made to eliminate the effects most likely to mask the true ionising potential, *viz.* photoelectric action and premature ionisation, and the negative current which persists if the gas pressure be not such that all electrons gaining energy corresponding to V_r are subject to effective collisions. H. H. Ho.

1263. *Further Studies in Ionisation: Hydrogen and Oxygen.* **H. D. Smyth.** (Roy. Soc., Proc. 105. pp. 116–128, Jan. 1, 1924.)—Recently the writer described a new method [see Abstract **2241** (**1923**)] for studying the ionisation of gases by electron impact and now presents data for hydrogen and oxygen. Both apparatus and procedure were identical with those used previously for nitrogen. It is found that ionisation in hydrogen at about 16·5 volts is not accompanied by dissociation as has been generally supposed. Atomic hydrogen atoms are first produced at a point 4·25 ± 0·06 volts higher than that at which molecular ions first appear.

The proportion of atomic ions remains very small up to 720 volts, the highest value used. If sufficiently high pressure be employed atomic ions predominate over molecular ions and appear at approximately the same voltage. This is interpreted as a secondary effect due to collisions of the ionised molecules with other molecules resulting in dissociation. Results are obtained in oxygen similar to those previously found in nitrogen. Molecular ions are produced at about 15·5 volts, doubly and singly charged atomic ions at about 7 and at 7·5 ± 0·2 volts higher, respectively. It is pointed out that these results can be interpreted by thermochemical equations such as were used for nitrogen, but that the results on hydrogen make the value of this procedure doubtful. A sharp increase in the proportion of atomic ions was found in the neighbourhood of 500 volts, but this result was greatly affected by the value of the magnetic field in the ionisation tube. H. H. Ho.

1264. *The Ionisation of Salt Vapours.* **W. M. Latimer.** (Am. Chem. Soc., J. 45. pp. 2803–2808, Dec., 1923.)—The heats of ionisation in the vapour state are calculated for the halides of hydrogen and the alkali metals. The ionisation constant calculated from this is found to be very small; for sodium chloride at the boiling-point it is 4×10^{-13}. The fields of force about the ions may be deduced from spectroscopical measurements, but the author shows that the heats of ionisation cannot be calculated by any method which treats the ions as rigid structures, as assumed by Born and his associates. B. W. C.

1265. *Electrical Conductivity of Phosphores and their Light Emission.* **B. Gudden** and **R. Pohl.** (Zeits. f. Physik, 21. 1. pp. 1–8, 1924.)—The authors disagree with Lenard, who is of the opinion that the conductivity produced in phosphores is not connected with phosphorescence, and their emission of light is unconnected with their conductivity. The authors [Abstract 914 (1921)] showed that there was a close connection and that both in excitation and emission a spatial movement of electrons takes place. When an elementary process ($h\nu$) occurs, an excited molecule remains as a positive ion, the electrons flowing towards the anode when liberated. The positive ion may also move slowly towards the kathode, but in a perfectly insulating crystal this does not occur and hence only half the quantum equivalent of electrons is obtained. The latter motion may, however, be caused by heating or by illumination by light of a frequency corresponding to the absorption spectrum of the crystal.

Large crystals should be employed, but phosphores are difficult to obtain in this state. The electronic current A remains constant so long as the supply of unexcited centres is nearly unaltered and a second current, as above, may be added, but usually the available centres are exhausted. The phosphores ZnSCuα, ZnSMn, and ZnSCuγ were investigated. The initial current is measured under illumination of wave-length 436 $m\mu$. This primary current reaches a steady value with the period of vibration of the electrometer, while with all three phosphores the current was roughly doubled when red light was used at the same time.

The results are compared with the experiments of Rupp [Abstract 1658 (1923)], who increased the emission, not by long wave-length radiation, but by heating, and showed that the total quantity of electricity would reach a saturation value with increasing voltage. This is supposed by the authors to confirm their view that the motion of the electrons in an electric field is identical with the mechanism of the photoelectric primary current. The authors criticise the calculations of Rupp concerning the currents observed by him on the grounds that he has, for instance, neglected the influence of the grain size of the crystals, while it is possible that, by heating, only the positive portion of the primary current may be released and the observed effects are still to be deduced on the assumption that quanta and electrons correspond to each other. Hence it is a matter of indifference whether the emission is increased by heating or by illumination with red light, the required saturation being also obtainable by the latter means. W. V. M.

1266. *Electric Discharge of very High Frequency.* **C. Gutton.** (Comptes Rendus, 178. pp. 467–470, Jan. 28, 1924.)—A continuation of previous work [Abstract 2240 (1923)] on high-frequency discharge in glass tubes containing dry air at low pressure; curves have been obtained representing as a function of the pressure, the difference of potential for which the tubes become luminous.

For periods above a certain critical period there is a pressure for which the difference of potential passes through a minimum, but for lower periods this minimum disappears, the difference of potential for which the discharge appears diminishing continually with the pressure. This diminution becomes very rapid at about the pressure which, for higher frequency, corresponds to the easiest passage of the discharge. Thus for wave-length 27 m. the difference of potential for which the tube is illuminated decreases as the pressure falls from 0·5 mm. to 0·05 mm, and then it increases rapidly for decreasing pressures to 0·005 mm. For a wave-length of 25 m. the difference of potential causing illumination decreases continuously with the pressure. W. V. M.

1267. *Discharge in Rarefied Gases.* **A. Pontremoli.** (N. Cimento, 26. pp. 115–121, Oct.–Nov.–Dec., 1923.)—After referring to the experiments of Wood [see Abstract 546 (1922)] with long tubes containing hydrogen, this paper discusses the subject generally, the part played by traces of water-vapour being discussed at some length. A. E. G.

1268. *Mechanical Force and Field Strength at the Kathode in a Discharge Tube.* **W. Braunbek.** (Zeits. f. Physik, 21. 3. pp. 204–218, 1924.)—It is shown that the force exerted on the kathode in an electrical discharge tube is due to an electric force, depending on the field intensity at the kathode, and an aerodynamic force which is due to pressure differences set up in the gas and the gas currents arising therefrom. A method is described which aims at the elimination of the force due to gas currents and measures only the electric force. From the value of the electric force (measured as mechanical pressure on the kathode) the field strength at the kathode was determined. For normal current-densities with a copper kathode in air the current-densities, mechanical force, and field strength were determined as a function of the pressure. The force for different pressures was found to be proportional to the normal current-density. From the normal kathode fall the mean field intensity in the dark-space was determined and compared with the field intensity at the kathode. The latter is always greater than the former. A. B. W.

1269. *The Dark Space at the Kathode for Induced Discharges.* **E. Goldstein.** (Zeits. f. Physik, 21. 4. pp. 252–253, 1924.)—In the "Jahrbuch der Radioaktivität und Elektronik," Seeliger has treated the sharpness of the boundary of the dark space at the kathode as a still unsolved riddle. The present author, however, claims to have settled this question long ago [see Abstract 101 (1901)] in the explanation then proposed for the occurrence of the dark space. He now sketches the essence of his theory on account of the general ignorance prevailing with respect to its existence. The dark space and the sharpness of its boundaries is held to depend on three facts: (1) From the static kathode proceed the ordinary (primary) kathode rays, which are free to move along their whole length and at the other terminus (Hittorf). (2) Every primary kathode ray is subject to a diffusion in the gas through which it passes whereby secondary radiation is formed (Lenard, Goldstein). (3) The kathode exerts a repulsion on all kathode rays (primary and secondary) (Goldstein). The author has explained the case of strong evacuation by means of this repulsion, whereby the primary kathode rays produce bright phosphorescent light where they strike the glass wall. At high densities only the gas particles are illuminated by them and their energy so abstracted. The argument is then developed that the dark surface on the glass wall is only developed for small gas densities. The so-called Crookes' dark space is then shown to be a repulsion phenomenon and the boundary up to which the diffuse radiation is continued is the sharp edge of this space. H. H. Ho.

1270. *Normal Kathodic Stream-Density.* **R. Seeliger** and **J. Schmekel.** (Ann. d. Physik, 73. 3-4. pp. 249-265, Jan., 1924.)—Holms' law of potential-similarity [see Abstracts 1311 (1915) and 331 (1919)] as to the normal density of kathode-streams is contradicted by measurements on spherical kathodes. A. D.

1271. *Calculation of Normal Kathode-Falls in Gas Mixtures.* **A. Günther-Schulze.** (Zeits. f. Physik, 21. 1. pp. 50-59, 1924.)—The author has already [see Abstract 2475 (1923)] published results obtained for the normal kathode-fall in gas mixtures. Some hypotheses have also been formulated on the kathode-fall in pure gases. In the present paper, by the aid of this former work, an attempt is made to calculate the normal kathode-fall in gas mixtures. A table is given showing the close accord between the calculated and measured values of the normal kathode-fall in Hg-Ar mixtures, using a graphite kathode. Mixtures of the noble gases with other gases are also considered. The results are shown by a series of graphs. A. E. G.

1272. *Doppler Effect in Line and Band Spectra of Canal Rays.* **H. Rau.** (Ann. d. Physik, 73. 3-4. pp. 266-271, Jan., 1924.)—A new method, conducive to facility and to comprehensiveness. A. D.

1273. *Photographic Action of Canal Rays.* **M. Jakobson.** (Ann. d. Physik, 73. 5-6. pp. 326-338, Feb., 1924.)—After a brief historical survey of work on the subject, this paper contains a detailed account of the apparatus employed, with a diagram showing the most important part of the final research arrangements. The other main parts of the paper are: The photographic material and its method of action; the separation of the direct action of the canal rays from the influence of the light sent out by them; the character of the photographic influence of canal rays. With very small times of exposure the canal rays cause a blackening which does not differ in principle in any way from the blackening produced by light. With increased time of exposure the blackening increases up to a known limit. The maximum blackening produced by the canal rays is much weaker than that produced by the action of light on the same kind of plate. Apparently the canal rays penetrate only into small depths of the light-sensitive layer. With longer time of exposure an appearance similar to solarisation is noticed. In the middle point of the blackened spot at the place where the most intense part of the canal rays falls a white spot appears after development. These solarisation appearances have already been observed previously by Königsberger and Kutschewski. Finally, when the time of exposure is still further increased, a further photographic influence of the canal rays is observed; within the white spots there enters after development a kind of island blackening. Photographs showing these points are given. A. E. G.

1274. *Mass-Spectra. Part. V. Accelerated Anode Rays.* **F. W. Aston.** (Phil. Mag. 47. pp. 385–400, Feb., 1924.)—A continuation of the work on mass-spectra from the end of 1922. The principal obstacle was the difficulty of producing the mass-rays of the metallic elements; only tellurium of the non-metallic non-radioactive elements has failed to give a mass-spectrum. Two new methods have been tried, (*a*) drawing out ions from metallic arcs and (*b*) using accelerated anode rays.

(*a*) An interrupted arc was formed by causing an iron wire to vibrate over the edge of a brass plate. In this way a strong discontinuous arc could be maintained for long periods, in a good vacuum. Attempts were then made to draw out ions using high potentials rectified through a valve, but without success, possibly because the fields employed, although very large, were not as high as local fields in the arc.

(*b*) A hot-anode method had already been applied in order to obtain the mass-spectra of the alkali-metals. The method now described is that of the composite anode of graphite and metallic salts.

In the final form of the apparatus the composite anode is carried in a pyrex tube, arranged so as to be easily withdrawn through the tube. A subsidiary kathode is opposite the anode, with a hole drilled, through which the anode rays may pass. This was mounted just in front of the earthed kathode of the mass-spectrograph. A rectified field was then put on through a valve, between the two kathodes, so as to accelerate the anode rays. A description of the procedure in obtaining an exposure is given. The working of the graphite paste anode is exceedingly capricious, but on favourable occasions has worked well, and is very widely applicable. The photographs are very faint, and sharp focusing is not possible, as relatively low exciting voltages must be used, so that they do not lend themselves to reproduction. But interpretation is easy, as practically no molecular lines appear, and a sufficient number of atomic lines are always present for reference, the most important being C^{12}, Al^{27}, Si^{28}, Fe^{56}, I^{127}. Li, Mg, Ca, Ge, Cu, Sr, Co, Sc, Mn, Ga, V, Cr, Ti, Ag, Y, Zr, and Hf were attempted by this method. The results given are: Sc^{45}; Ti^{48}; V^{51}; Cr^{52}; Mn^{55}; Co^{59}; Cu^{63} and Cu^{65}; Ga^{69} and Ga^{71}; Ge^{74}, Ge^{72} and Ge^{70}; Sr^{88}; Y^{89}; Ag^{107}, and Ag^{109}. Unfortunately the Ti, Zr, Hf group seems the hardest group to deal with; a faint suggestion of a line at 90 was seen, for Zr, but no trace of any Hf line. Experiments with niobium, molybdenum, cadmium, and lead were negative. A slight trace of a Ba line was found in the expected position [see Abstract 673 (1924)]. A. C. M.

1275. *Experiments with a "Glim" Lamp as a Detector of Ionising Radiations.* **O. v. Baeyer** and **W. Kutzner.** (Zeits. f. Physik, 21. 1. pp. 46–49, 1924.)—The usual apparatus for detecting ionising radiation has disadvantages. For example, the Geiger counter is easily damaged and the space through which the radiation must pass is limited. A glow-lamp, or best of all a so-called microphone lamp, is easy to use, and when connected in series with a high resistance (1–10 megohms) to a circuit at 150–200 volts it lights up on the entry of the radiation. In order to arrange for its extinction a condenser is included. Arranging so that no oscillations occur, the lamp, having a U-shaped iron anode with an iron plate as kathode, lights up irregularly on bringing near it α-, β-, or γ-ray preparation. The lamp may also be excited by light, and the iron shows photoelectric effects for waves which pass through the glass of the lamp, *e.g.* in the region of 380 *mμ*, whereas the usual limit is given as 287 *mμ*. A lamp containing potassium showed enormous sensitiveness, possibly connected with the radio-active properties of that metal.

W. V. M.

1276. *Physical Physiology. Illumination of Vacuum Lamps by Friction.* **H. Cardot** and **H. Laugier.** (Comptes Rendus, 178. pp. 649–652, Feb. 11, 1924.)—The explanation of a mysterious effect is given in which lamps containing nitrogen, argon, or neon are made to illuminate when in the hand or even at a distance. The effect is shown to be due to a frictional charge when the performer has a dry skin; the effects depend upon the humidity of the atmosphere, etc., and were proved to be in some circumstances beyond the performers' actual control. B. J. L.

1277. *Oscillations in the Low Voltage Helium Arc.* **C. H. Eckart** and **K. T. Compton.** (Science, 59. pp. 166–168, Feb. 15, 1924.)— R. Bär, M. v. Laue, and E. Meyer have recently [see Abstract 615 (1924)] explained the apparent maintenance of the helium arc at voltages below the first radiating potential. Contrary to the conclusions of Bär, v. Laue, and Meyer, the present authors have not found inductance in the circuit to be essential, although the presence of inductance or capacity has an effect on the frequency of the oscillations and their wave form. Two distinct types of oscillation are found in the arc. (1) A type which appears when the direct-current voltage across the tube begins to diminish with increasing current. This type is characterised by (*a*) the maximum voltage (about 28 volts) is above the ionising potential; (*b*) the minimum voltage (about 16 volts) is below the first radiating potential; (*c*) the direct-current voltage is much nearer the maximum voltage than the minimum; (*d*) the amplitude of oscillation shows no marked variation as the resistance in the circuit is changed. When the direct-current voltmeter reading is reduced below about 25 volts, these oscillations stop suddenly, and the arc is maintained without noticeable oscillations at about 20 volts. On decreasing the series resistance further, the voltage drops a few tenths of a volt, and the current rises, but no oscillations are detectable. (2) On further decreasing the series resistance oscillations again set in. In this type (*a*) the maximum voltage is above the first radiating potential, and below the ionising potential; (*b*) the minimum voltage is below the first radiating potential; (*c*) the reading of the direct-current voltmeter is usually nearer the minimum than the maximum voltage; (*d*) the amplitude showed a marked maximum at the minimum of the direct-current voltage curve. An explanation of these phenomena is offered. A. E. G.

1278. *The Potential Gradient in the Sodium-Potassium Vapour Arc Lamp.* **F. H. Newman.** (Phil. Mag. 47. pp. 603–608, March, 1924.)—A sodium-potassium vapour arc lamp similar in principle to the more familiar mercury-vapour lamp has been previously described by the author [see Abstract 327 (1923)]. This lamp works with a relatively small applied p.d.—the arc can be struck with 30 volts—and when once the arc has been started the fall of potential between the terminals is only 10 volts with a current of 1·5 amp. This potential difference is very small when compared with the carbon arc, and is less than that required to operate the mercury-arc except the low-voltage arc in mercury-vapour, which acts on a different principle. A diagram of the quartz tube used in the present investigation is given. The probe method is employed for ascertaining the distribution of electron force along the arc of the lamp. The results obtained show that the potential gradient along the arc column is uniform, and therefore, as shown by Poisson's law, there cannot be a preponderance of ions of one sign or the other in it. The kathode fall—3·8 volts—is greater than the anode fall—2·5 volts—but both are small compared with the results for other metal electrodes. The small p.d. between the terminals of the lamp when it is working is explained by the photoelectric effect exhibited by the alloy. A. E. G.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1279. *Increase of Resistance of a Conductor for Alternating Currents.* **L. Lehrs.** (Archiv f. Elektrot. 12. pp. 443–452, Feb. 29, 1924.)—Describes in detail apparatus suitable for comparing the resistances of a coil for alternating and continuous currents. The currents are adjusted to give the same Joule heating effect in both cases, and are measured. The ratio of their inverse squares gives the ratio of the resistances. For alternating currents of wave-lengths 900, 437, 210, 135, and 115 metres the percentage increases over the resistance for a direct-current are found to be 66, 160, 254, 330, and 380 respectively. G. A. S.

1280. *Validity of Ohm's Law for an Electrolyte with High-Potential Gradients.* **M. Wien.** (Ann d. Physik, 73. 3–4. pp. 161–181, Jan., 1924.)—A more complete account of work previously described [see Abstract 789 (1923)]. G. A. S.

1281. *The Alteration of the Temperature Resistance Coefficient of Pure Platinum under Mechanical Stress.* **O. Feussner.** (Zeits. f. Physik, 21. 3. pp. 163–167, 1924.)—Describes experiments in which loads, varying from 0 to 120 grammes, were applied to a platinum wire of 0·01 mm. diameter, placed in an oil bath the temperature of which was raised from 0° C. to 100° C., and the resistances were measured and compared with those of a similar wire in the same bath, which remained unloaded. The ratio of R_{100} to R_0 was only altered very slightly by the loading. When, however, a platinum wire is drawn through a die the temperature coefficient is in general considerably altered. H. N. A.

1282. *Electric Polarisation of a Dielectric.* **G. Jacoby.** (Ann. d. Physik, 73. 5-6. pp. 477-482, Feb., 1924.)—Mathematical supplement to former paper [Abstract 143 (1924)]. The evaluation of path-radii for atoms above the order 2 is indeterminate. A. D.

1283. *Dielectric Constants of Organic Liquids.* **F. V. Grimm** and **W. A. Patrick.** (Am. Chem. Soc., J. 45. pp. 2794-2802, Dec., 1923.)—With numerous precautions dielectric constants of 35 organic liquids are found at their boiling-points under normal pressure. The authors conclude from their results that no generalisation of any value connecting dielectric constants with other properties of liquids has yet been formulated. A method of evaluating the volume occupied by the molecules in the liquid state is suggested and the results are given of applying this to Bakker's equation for the latent heat of vaporisation. G. A. S.

1284. *Influence of the Support on Measurements of the Surface Resistance of Insulating Sheets.* **R. Dieterle.** (Elekt. Zeits. 45. pp. 132-133, Feb. 21, 1924. From the Reichsanstalt.)—According to the specifications of the V.D.E. tests of surface insulation resistance are to be made on specimens of material measuring 12 cm. × 15 cm. × 1 cm. thick between two knife-edge electrodes 10 cm. long set parallel to one another on the surface at a distance of 1 cm. apart. One electrode is earthed and the other raised to a high direct voltage, the leakage current being measured by a sensitive galvanometer. The specification further provides that the test specimen shall rest on an insulating support and not on an earthed metal plate. [See Abstract 335B (1923).] The flow of current between the electrodes consists mainly of the surface leakage, but a certain number of lines of flow pass between the electrodes into the sheet; the measured current is the sum of these two currents, the second being usually small. If the test specimen be insulated the flow takes place symmetrically between the electrodes, whereas if the sheet be laid on an earthed metal plate the flow of current in the sheet is distorted. Some of the current flowing into the specimen passes to the earthed support and is not measured by the galvanometer, and the measured resistance will be too high. The paper gives results of tests to show the magnitude of the effect on the insulation resistance of earthed and insulating supports. The influence of earthing is greatest when the volume resistance and true surface resistance are of similar order and with thin specimens. The effect is negligible in the case of good insulators even if so thin as 1 mm., but considerable differences may occur in tests on poor insulating materials, even if the samples are thick. B. H.

1285. *Resistances of Wires for High-Frequency Alternating Currents.* **G. Wuckel.** (Ann. d. Physik, 73. 5-6. pp. 427-456, Feb., 1924.)—To measure alternating-current resistances of wires for oscillations of wave-length varying from about 4 to 5 metres use is made of the fact that if a Lecher wire system is closed by a suitably chosen end-resistance it is equivalent to a system of infinite length, in which stationary waves due to reflection from the end are absent. In this case the falling off in energy along the wires is connected in a simple way with their resistance by equations which are well known. The greatest difficulty of the method is to provide a suitable form of end-resistance, since, to fulfil the required conditions, the contributions of the real and imaginary terms must be capable of separate variation. A simple wire or a liquid resistance is unsuitable, but a second system of Lecher wires, closed at the end and having a condenser in parallel with it, can be made to conform to the requirements and is found to be satisfactory. A graphical method gives the approximate length of this end-system and the value of the capacity of the condenser, which are then adjusted accurately by trial. Such a resistance is found to reduce fluctuations in energy due to end reflection to a very small percentage, of the same order as unavoidable variations due to other causes.

By a device that is described the falling off in energy along the wires is measured, and the resistance is calculated. Results are given for wires of constantan, brass, German silver, Nickelin, varying from 0·2 to 1 mm. in diameter, for wave-lengths of from 3·9 to 5·5 metres. These agree within limits of ± 0·15 ohm/metre with the values deduced from the continuous-current resistances, using Zenneck's theory. G. A. S.

1286. *A Compensated Shunt for Use with a Vibration Galvanometer.* **H. Schering** and **G. Reichardt.** (Archiv f. Elektrot. 12. pp. 493–497, Feb. 29, 1924. From the Reichsanstalt.)—In a.c. bridge measurements in which a vibration galvanometer is used as the detector it is desirable at the beginning of the test, when the correct setting of the bridge is quite unknown, to reduce very considerably the sensitivity of the instrument. Then, as balance is gradually approached, it is required to increase the sensitiveness by a series of not too widely spaced steps up to the maximum value. The paper describes a new type of compensated shunt box which attains the required result. A set of resistances, controlled by a rotary switch, are connected up for use in accordance with the principle of the well-known Ayrton-Mather universal shunts. Operation of the switch at the same time inserts in series with the whole combination suitable compensating resistances, so that the sensitivity for successive positions of the rotary switch is adjusted in a number of steps in geometric progression. Such values are chosen as make the regulator applicable to galvanometers of high or low resistance whether in use with high- or low-resistance bridges. The resistances are also designed to produce the required result with the least amount of resistance wire. A table of resistance values for a shunt giving a sensitivity ratio of 5 is given together with a schematic diagram of connections. B. H.

1287. *Anomalous Behaviour of a Vibration Galvanometer.* **E. V. Appleton.** (Phil. Mag. 47. pp. 609–619, March, 1924.)—This paper describes certain peculiar characteristics of a moving magnet vibration galvanometer of the Drysdale-Tinsley pattern. Experiments with the instrument had shown that, at a fixed frequency, one of two possible deflections could be obtained for a given current. A set of curves giving the relationship between deflection, current and frequency is reproduced, showing the peculiar feature mentioned and also a region of instability. In general, therefore, there are three amplitudes corresponding to a given current, two being stable and the third unstable. The effect is ascribed to the presence of "oscillation hysteresis" arising from non-linear relations between the restoring force acting on the moving magnet and on displacement of the latter. Consideration of the design of the galvanometer shows that such non-linear forces are to be expected due to

(i) reduction of pole strength of the vibrating magnet with increase of amplitude; (ii) proportionality of restoring force to sin θ rather than to θ; (iii) non-uniformity of the polarising field of the fixed permanent magnet. An approximate theory of forced oscillations of the moving system, taking these facts into account by means of a correction term proportional to θ^3, is attempted. Regions of stable and unstable oscillation are deduced and a set of theoretical resonance curves showing two stable amplitudes and one unstable amplitude for a given current are drawn, the latter curves reproducing the characteristic features of those obtained by experiment. B. H.

1288. *New Form of Electrometer.* **F. A. Lindemann, A. F. Lindemann, and T. C. Keeley.** (Phil. Mag. 47. pp. 577–583, March, 1924.)—The principle of this instrument is the same as that of the quadrant electrometer. The needle, however (which here really has the form of a needle), is fixed to the centre of the torsion fibre, this latter being gripped both at top and bottom. This method of suspension enables the instrument to be used in any position without affecting its sensitivity or the constancy of its zero. In consequence the instrument may be used with great advantage in connection with a photoelectric cell for the measurement of stellar light values, as both cell and electrometer may be fixed rigidly together just behind the focus of the equatorial. The conditions governing the sensitivity are worked out in detail, and data are given with regard to one instrument showing that it has about the same sensitivity, but a smaller capacity and period, than the ordinary form of the Dolezalek electrometer. A. A. D.

1289. *The Significance of Labilisation in the Electrometric Measurement of Small Quantities of Electricity.* **G. Hoffmann.** (Phys. Zeits. 25. pp. 6–8, Jan. 1, 1924.)—The charge and deflection of an electrometer are considered in two stages: (*a*) The potential change during the charging of a stationary instrument; (*b*) the oscillations and equilibrium position. A comparison is then made between the thread and quadrant electrometers with respect to the measurement of small charges. Advantage is now taken of instability factors (labilisation) to improve sensitiveness and constitutes a new development in electrometric measurement technique. These factors are discussed at length. H. H. Ho.

ALTERNATING CURRENTS AND MAGNETISM.

1290. *The Calculation of Conductivity.* **C. F. Weiland.** (Elekt. Zeits. 45. pp. 208–210, March 13, 1924.)—This paper attempts to give a review of the e.m.f. and energy relations in alternating-current conduction, and contains a complete and simple graphical method for the exact evaluation of conductivities, which is claimed to be exact and inclusive of all the characteristic cases. The paper is entirely mathematical. H. H. Ho.

1291. *Mutual Impedances of Earthed Circuits.* **G. A. Campbell.** (Bell System Techn. J. 2. pp. 1–30, Oct., 1923.)—A mathematical paper in which the author obtains expressions for the mutual resistance and inductance between circuits using an earth return, the calculations being based on the assumption that the circuits are traversed by continuous currents. In the case of horizontal co-planar conductors above, below or on the surface of the earth, the mutual inductance for filamentous circuits is expressed by Neumann integrals of comparatively simple form, and numerical values of these are readily obtainable from the accurate graphs which accompany the paper. The calculated continuous-current values are shown to form useful first approximations to a.c. values in many practical cases. A. H.

1292. *The Diurnal Fluctuation of the Horizontal Intensity.* **J. Bartels.** (Meteorolog. Zeits. 40. pp. 301–305, Oct., 1923.)—The diurnal variation u of the horizontal intensity is well suited to be the measure of the mean value of the earth's magnetic activity during longer intervals of time. To the hitherto brought forward measures u is to be preferred on account of its somewhat greater regularity at the various stations and of the far easier calculation which in case of necessity can be referred to the estimated middle of the day. The correlation with the relative numbers of sunspots is very close. As universal measure the daily variation U of the perturbation is proposed. It is calculated from the north component X for each station at $U = u(X) : \sin\theta \cos\psi$. J. J. S.

1293. *Effect of Shape of Magnet on Remanent Magnetism.* **A. Michel and L. Veyret.** (Rev. Gén. d'Él. 15. pp. 43–52, Jan. 12, 1924.)—A study of the horse-shoe magnet with semicircular arch and parallel limbs. In the first group of tests, it is found that for given sectional area, s, distance between axes, d, and height of axis, h, the intensity of remanent magnetism is independent of the shape of the section. With variation of h, s, and d respectively, it was found that I increased with h towards the limit determined by a closed ring; for given h and d, I varies inversely with s; with given h and s, I passes through a minimum as d increases. In the next test, the weight of the magnet is plotted against the flux, ϕ, at the middle of the magnet, and the minimum weight for a magnet of given section and flux is found. Magnets of maximum output have $I = 575$ (± 10 per cent.) at the middle on open circuit. For ordinary magnets, the ratio $h/\sqrt{s}$ is about 6·5, and varied in the above tests between 4·5 and 7. From a hysteresis graph done on a ring of the steel employed (a normal tungsten steel with $I_s = 1200$, $I_r = 850$, and $H_c = 65$), and a calculation of demagnetising factor, expressions are obtained for the remanent magnetism in a horse-shoe magnet, with and without armature, in terms of h, s, and d. G. E. A.

1294. *Magnetic Viscosity.* **C. Lapp.** (J. de Physique et le Radium, 4. pp. 349–369, Oct., 1923.)—Employing a ballistic method with rings of electrolytic iron, a special device is used by which (*a*) a strong magnetising current is broken at zero time, (*b*) an equal reversed current is established after a known time interval, and (*c*) at the same instant the secondary circuit of the ballistic galvanometer is automatically closed. The viscous effect tends to increase the magnetisation, but it disappears in strong fields; according to Jouaust, viscosity is observable within the field limits + 3·3 and − 8·7 gauss; the author places these limits at + 1·5 and − 6 gauss. Using six rings, families of B,H curves are drawn in which the variation of B with time is plotted for separate values of H. The total induction $B = B_\infty + B'$, B_∞ the value found for a slow cycle, and B' the part depending on the time t, and expressible in terms of the amplitude λ by $B' = \lambda s^{-\beta}$. In weak positive fields, the duration and amplitude of the viscous effect are very small; they increase in increasing negative fields, and maximum duration occurs in the coercive fields; the duration then diminishes, the amplitude continuing to increase, then slowly decreasing; finally the effect becomes unobservable when its duration becomes less than $\frac{1}{8}$ second. The BH*t* changes are represented by means of a surface of viscosity. Isochronous cycles are obtained for the rings, from which, by extrapolation, is obtained the instantaneous value of the field, *i.e.* the difference between the slow and the instantaneous cycle, for given induction at zero time. The cycles thus formed show that the energy dissipated in the instantaneous cycle is greater than that spent in a slow cycle. The value of H_c is less than 0·5 gauss for the slow cycle, but viscosity may cause it to attain a value of from 3 to 12 gauss and the area of the cycle is increased four to five times. [See also Abstract 1516 (1913).] G. E. A.

1295. *Magnetic Properties of Nickel-Chromium Alloys.* **J. Safránek.** (Rev. de Mét. 21. pp. 87–111, Feb., 1924) and summary of results only (Comptes Rendus, 178. pp. 479–480, Jan. 28, 1924.)—A series of alloys is prepared from pure nickel and electrolytic chromium in a high-frequency induction furnace. An account of the preparation of the chromium is given. The magnetic properties of these alloys below the Curie point are then investigated. The interest in the research lies in the fact that the alloys are between ferro- and para-magnetic metals; the cases of ferro-ferro-, and ferro-dia-magnetic alloys having been already worked out. A survey of the theory of magnetisation is given with derivations of Curie's and Weiss' laws and a full description of the apparatus used in this work. The specimen is held in a quartz holder in a non-uniform magnetic field, the holder being attached to a frame slung at two points and so capable of horizontal displacement. Damping is effected by a plate fixed to the suspended system perpendicular to the direction of motion and close to a fixed plate, while a balance of the force is attained by mounting on the moving system a coil carrying a constant small current. This is coaxial with two coils carrying a current which is continuously variable. The specimen and support are surrounded by a water-jacketed heating coil in which temperatures up to 1000° C. can be maintained and measured by a thermo-couple. For nickel the Curie point is 658° K., the Curie constant 0·0055 and the number of magnetons below the Curie point 7·99. The susceptibility of chromium is $4{\cdot}31 \times 10^{-6}$ and is constant between 2000–14,000 gauss and from 100°–600° C. Graphs of these quantities for alloys up to 14 % chromium and some data for low temperatures are given. The main paper concludes with tables and a bibliography. A. Wh.

1296. *The von Ettingshausen Effect.* **E. Persico.** (N. Cimento, 26. pp. 123–133, Oct.–Nov.–Dec., 1923.)—The transverse temperature across a lamina of bismuth in a magnetic field normal to it and traversed lengthwise by a current (the von Ettingshausen effect) is explained by the electrodynamical action of the magnetic field on the corpuscles which carry the current. But there must be another effect of the same nature, differing from the former in respect that its amount is proportional to the cube of the current-strength; and this new effect is due to a superposed magnetic field. The amount of the new effect is generally a little less than the limit of experimental error; but under particular conditions it may assume preponderating values. A. D.

1297. *A Formula for the Specific Heat of Ferromagnetic Substances and its Discontinuity at the Critical Temperature.* **J. R. Ashworth.** (Nature, 113. pp. 13–14, Jan. 5, 1924.)—The loss of magnetism by a ferromagnetic substance at its critical temperature is accompanied by a sudden diminution in the value of its specific heat. Applying van der Waals' equation of state to ferromagnetism, the author has obtained formulæ giving the value of the specific heat at the critical temperature and its change on loss of magnetism. Values for Fe, Ni, and magnetite calculated according to these formulæ agree more closely with observed values than those calculated by aid of formulæ due to Lorentz which are based on the theories of Langevin and Weiss. L. L.

1298. *Magnetic Waves in Iron Rods and Rings.* **A. Karlsson.** (Ark. f. Mat., Astron. och Fysik, Stockholm, 17. No. 13. pp. 1–13, 1922–1923. In English.)—When a long iron rod is magnetised over a limited portion by an alternating current in a short solenoid, there is a phase retardation (ϕ) of the flux, at a distance (x) along the rod, behind the momentary flux at the centre of the magnetising solenoid. Oberbeck found (1884) the retardation per unit length (γ_1) to be constant along the rod. Lyle and Baldwin showed that ϕ is at first proportional to x, reaches a maximum, and then diminishes, and that the leakage coefficient of the wave is subject to a similar variation [see Abstract 2091 (1906)]. The author, by considering the effect at x to be due to two magnetic waves, one transmitted with the velocity of light and with very slight leakage, while the other moves with smaller velocity and with considerable leakage, finds an equation for ϕ and x, *viz.* $Ae^{px} = \sin(\phi - \phi_1 - \gamma_1 x)/\sin(\phi_2 - \phi)$, in which A, p, γ_1, ϕ_1, and ϕ_2 are constants. Employing a three-phase motor with fixed armature as a phase-meter, a part of the current from a delta-connected three-phase generator was led into the magnetising solenoid, and the other part excited the field in the phase-meter. The induced current from the latter was passed through the fixed coil of a dynamometer whose moving coil was connected with a search coil that could be moved along the

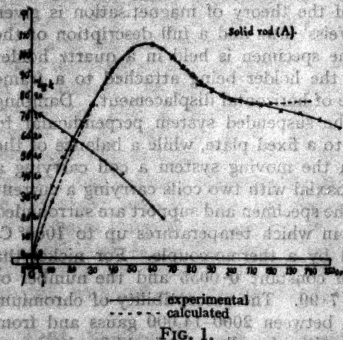


FIG. 1.

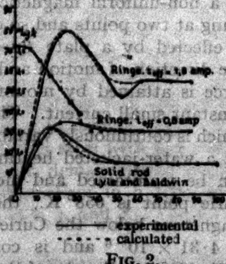


FIG. 2.

specimen. The position of the armature for no deflection was noted on a scale of degrees and gave the phase-difference between the two currents. It was found that the higher harmonics did not affect the dynamometer. The results are given in tables and curves (see figs.). The position of the maximum on the phase curve depends on the strength of the current in the solenoid; also the form of the curve is affected by the frequency (40 to 50 used). The maximum is nearer the solenoid for a tube than for a solid bar; also γ_1 is less for the tube than for the bar; γ_1 thus increases in the same degree as the Foucault currents. No alteration was found in the form of the phase curve when a ring specimen was straightened out. G. E. A.

1299. *Magnetic Testing of Small Specimens.* **T. F. Wall.** (Engineering, 117. pp. 293–295, March 7, 1924.)—The ring ballistic method is applied to short tubular specimens 1 in. long with outer diam. $\frac{5}{8}$ in. and inner diam. $\frac{7}{16}$ in. These are wound with primary and secondary, and a diagram gives the connections required to obtain the magnetisation and demagnetisation curves. As a large current is required for the maximum field of 2000 gauss, the specimen is immersed in oil; also a special switch is used to short-circuit the secondary immediately after the discharge through the galvanometer is complete. The exciting circuit may then be broken after carrying the maximum current for only a few seconds. B,H curves are given for stalloy, cobalt-chromium magnet steel, and permanite. The permanent magnet steels are also compared by Evershed's method by plotting $BH/8\pi$ with B for the demagnetisation curves. These curves give values for the maximum available energy in ergs per c.c. For cobalt-chromium containing 9 % Co, 9½ % Cr, 1 % C, $H_c = 180$, $B_r = 8300$, max. available energy = 26,200. For permanite, $H_c = 138$, $B_r = 9800$, max. energy = 24,200. [See also Abstract 113 (1916).] G. E. A.

1300. *Criterion for Anomalies in Earth's Magnetism.* **P. Lasareff.** (Comptes Rendus, 178. pp. 627–630, Feb. 11, 1924.)—The author compares the magnetic intensities at a point due (*a*) to a linear current (*b*) to a line of similar poles uniformly distributed. In both cases the line is taken parallel to the surface of the earth, and its projection on the surface is called the fundamental line of the anomaly. Expressions are found for the horizontal and vertical components, H_a and Z_a, of the fields produced, and the case is extended to that in which several lines may occur. The vectors of H_a are always perpendicular to the fundamental line, but for a line of magnetic poles the vector changes sign as it crosses the line. Applying this to terrestrial declination, the fundamental line separates a region of westerly declination from one of easterly declination when the disturbance is due to a magnetic cause. In the case of an electric current, the isogonals are inflected as they cross the fundamental line. In the region of the anomaly at Koursk, the distribution of Z, H, and D indicates the existence of a magnetic source of disturbance. G. E. A.

1301. *Austrian Magnetic Survey in the Balkans in* 1918. **A. Schedler.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 10. pp. 643–654, 1922.)—The region surveyed included Montenegro, Albania, and that part of Serbia west of the Morava and Vardar rivers, thirty stations being chosen. Laboratory tests of the instruments were made in

Potsdam and Pola. The apparatus carried included two chronometers, a portable "universale," magnetic theodolite, dipping needle, and declination needle. The value of H was measured chiefly by a deflection method, and the values of the elements are tabulated for the different stations as for the beginning of 1918. The declination increases from east to west, varying from 3° 41′ at Belgrade to 5° 20′ at Niksic, with a disturbed region round Uziče where the declination is 7° 26′. The dip varies from 56° 1′ at Ljusna to 59° 47′ at Bazias, whilst H is ·22416 at Sabac and ·24234 at Ljusna. Maps of isogonals, isoclines, and isodynamics are appended along with a map of the route and a geological sketch map of the disturbed region round Uziče; the disturbance is due to the presence of chromium-iron ores at Zlatibor. G. E. A.

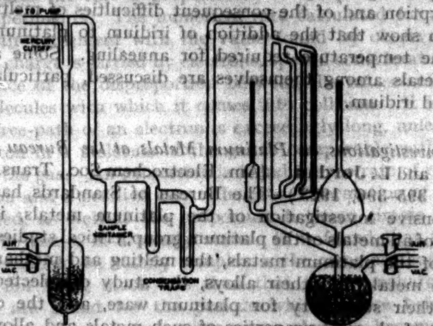
1302. *Magnetic Survey of Austria in* 1918. **A. Schedler.** (Akad. Wiss. Wien, Ber. 131. 2a. No. 10. pp. 655–665, 1922.)—The present partial survey is based on that of 1890 by Liznar, who showed that the distribution of magnetic force may be calculated from observations at a comparatively small number of stations by employing the values found during a previous survey. The present measurements relate to stations between the meridians 9° 30′ and 18° east of Greenwich, and the instruments were those carried in the Balkan survey [see preceding abstract]. In the absence of triangulation marks, sun observations were necessary to determine the meridian. Values of the elements are given for twelve stations for the beginning of 1918; the elements are then calculated for the remaining eighty stations of the former survey by Liznar's method. The secular variation of the dip is − 10′ to − 30′, and is greatest in the west and south where also H has increased by more than 150 γ. In the east and north-east, H has diminished by about 70 γ, the line of no variation passing through St. Johann in Tirol, Klagenfurt, and Marburg. Maps of smoothed isogonals, isoclines, and isodynamics are given. G. E. A.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1303. *Chemical Nature of Purple of Cassius.* **A. Huber.** (Phys. Zeits. 25. pp. 45–47, Jan. 15, 1924.)—Application to purple of Cassius of Debye and Scherrer's X-ray method yields an impression, analysis of which shows that this substance does not contain gold in chemical combination but consists of a mixture of colloidal gold and colloidal stannic acid. T. H. P.

1304. *Isotopy and the Isotopes.* **(Mme.) P. Curie.** (J. de Physique et le Radium, 4. pp. 381–412, Nov., 1923.)—Contains an account of the relations between the radio-active isotopes, and of the discovery of the isotopes of the stable elements. The various proposed methods of separation are discussed. H. N. A.

1305. *Gases Evolved from Glasses of Known Chemical Composition.* **J. E. Harris** and **E. E. Schumacher.** (Bell System Techn. J. 2. pp. 122–132, Jan., 1924.)—The gases may be held as an adsorbed film or dissolved throughout the glass. Adsorbed gases are evolved readily at temperatures less than 300° C., but dissolved gases come out slowly owing to the slowness of diffusion through the glass, even at much higher temperatures. The principal gases held are carbon dioxide, water, sulphur dioxide, oxygen, and nitrogen. A general view of the apparatus employed for determining the gases evolved from glass on being heated is shown. Water-vapour was removed by surrounding the condensation traps with a mixture of frozen and liquid acetone. Carbon dioxide was removed by liquid air. The authors describe the method of determining the amount of gases given up by various types of glass when heated, the time varying from 65 to 80 hours. The results are as follows: (1) Glasses whose compositions run high in alkali give off more gas during heat treatment than those of lower alkali content; (2) a definite relation appears to exist between the amount of water-vapour held by



a glass and its alkali content; (3) a relation appears to exist between the amount of carbon dioxide held by a glass and its alkali content; (4) adsorbed carbon dioxide seems to be held to glass primarily by primary valence forces; (5) adsorbed permanent gases seem to be held to glass primarily by secondary valence forces; (6) glass relatively free from absorbed gas can be produced by heating the glass during its melting process to a sufficiently high temperature. T. C. H.

1306. *The Diffusion of Hydrogen through Metals.* **H. G. Deming** and **B. C. Hendricks.** (Am. Chem. Soc., J. 45. pp. 2857–2864, Dec., 1923.)—An apparatus is described for the study of the rate of diffusion of gases through metal sheets, which allows a definite area to be exposed at any desired temperature. The specific diffusion rate of hydrogen through aluminium, zinc, lead, copper, and nickel, is determined at various temperatures. For copper and nickel, which show the highest rate, measurements are made over a considerable range of temperature. The curves obtained are of the same form as those obtained by previous workers on this subject. [See Abstract 1516 (1920).] B. W. C.

1307. *Metals of the Platinum Group.* **F. E. Carter.** (Am. Electrochem. Soc., Trans. 43. pp. 397–408, 1923.)—Some general remarks on metals of the group are given, particular mention being made of the liability to gas absorption and of the consequent difficulties of melting. Results are given to show that the addition of iridium to platinum raises considerably the temperature required for annealing. Some alloys of the platinum metals among themselves are discussed, particularly those of platinum and iridium. AUTHOR.

1308. *Investigations on Platinum Metals at the Bureau of Standards.* **E. Wichers** and **L. Jordan.** (Am. Electrochem Soc., Trans. 43. pp. 385–395; Disc., 395–396, 1923.)—The Bureau of Standards has undertaken a comprehensive investigation of the platinum metals, involving the purification of all metals of the platinum group, critical studies of analytical separation of the platinum metals, the melting and mechanical working of the pure metals and their alloys, the study of selected alloys with respect to their suitability for platinum ware, and the determination of a variety of physical properties of such metals and alloys. The first three phases of this investigation are actively in progress; the last two phases are to be undertaken in the immediate future. AUTHOR.

1309. *The Conversion of Diamonds to Graphite at High Temperatures.* **M. de K. Thompson, P. K. Frölich,** and **J. L. Gillson.** (Am. Electrochem. Soc., Trans. 43. pp. 161–166; Disc., 166–170, 1923.)—It is shown conclusively that diamonds change slowly at 1650° C. to a substance that gives the Brodie test for graphite, and that the velocity of this reaction is increased about 26 times by an increase of 100° above this temperature. AUTHOR.

1310. *Photochemical Sensitisation of the Ethyl Maleate Rearrangement by Bromine.* **J. Eggert.** (Phys. Zeits. 24. pp. 504–506; Disc., 506–510, Dec. 1 and 15, 1923. Paper read before the Deut. Physikertag, Bonn, Sept., 1923.)—The experiments here described consisted in diluting ethyl maleate with carbon tetrachloride, adding a solution of bromine in the same solvent, subjecting the mixture to the action of a definite amount of luminous energy of certain wave-length, and analysing the resulting mixture of ethyl maleate and fumarate by means of the melting-point. The results obtained show that neither the carbon tetrachloride, nor the ethyl fumarate formed, nor the inactive bromine takes part in the reaction, the course of which is independent of the molecular concentrations of each of these three substances. The bromine first absorbs light and becomes active, and then effects the rearrangement of the maleic acid to fumaric acid. The dependence of the process on the temperature indicates that, of the maleate molecules which encounter the active bromine, only those undergo isomerisation which possess more than a definite critical energy. T. H. P.

1311. *The Physical Chemistry of the Photographic Process.* (Faraday Soc., Trans. 19. pp. 318–326, Nov., 1923.)—Discussion on various papers referred to in Abstracts 831, 1011, 1012, 1013, and 1014 (1924.)

1312. *Recombination of Gaseous Ions, the Chemical Combination of Gases and Monomolecular Reactions.* **J. J. Thomson.** (Phil. Mag. 47. pp. 337–378, Feb., 1924.)—Expressions are developed for the rate of recombination of positive and negative ions from which it follows that at low pressures the rate is proportional to the pressure, as is found in Thirkill's experiments. The numerical rate calculated for air at N.T.P. is in very fair agreement with the value found by observation. When the negative charge is carried by electrons, special consideration is required in consequence of the disproportion between the masses of the electron and the molecules with which it comes into collision. It is shown that the energy free-path of an electron is exceedingly long, unless the energy of the electron in a molecule of the gas is comparable with the ionising potential of the gas. An expression is found for the rate of recombination of an electron and a positive ion. The rate of formation of complex ions is investigated, as well as the proportion between simple and complex ions when the gas is in a steady state. It is found that the condition that the ions should be mainly complex is the same as that for the free-path of an ion being much less than that of an uncharged molecule. Expressions are found for the periods which elapse before a simple positive ion becomes a complex one or an electron becomes a negative ion, the values obtained for the latter being of the same order as those obtained in Loeb's experiments. By application of the same principles to chemical combination, expressions are found for the rate of combination of two gaseous systems and for the rate of dissociation of the resultant compound, the former being of the same form as that for the recombination of positive and negative ions, the rate at lower pressures being proportional to the pressure. The rate of decomposition of the gaseous compound is determined on the hypothesis that it is due to collisions; the objections which have been urged against this type of dissociation are shown not to be valid when combination takes place in the way assumed. The effect of polar molecules in hastening chemical combination is investigated and found to be very large. An expression obtained for the rate of monomolecular reactions in solids, *e.g.* sublimation, indicates the great influence of surfaces such as the walls of the containing vessel on the rate of chemical reaction. A. B. C. L.

1313. *The Quantitative Relation between the Intermittent Alteration of Atoms and the Harmonic Components of their Changes of Mass. Part II.* **K. Fehrle.** (Zeits. f. Physik, 21. 3. pp. 219-222, 1924.)—This paper is a continuation of previous work [see Abstract 420 (1924)]. The position of the separate harmonic components is established with respect to the axis about which the potential energy is a minimum, and 18 harmonics are dealt with, which include 4 elements per wave-length. For stable equilibrium when 4 ordinates follow at distances of 90°, the arguments are given by the formula $(2n + 1)\ 45°_{n = 0, 1, 2, 3}$, so that the sum of the $|\cos|$ is a maximum. The mass alteration per unit time for the n harmonics is given by $\partial y/\partial t = 2\pi \,.\, nA_n \cos (2\pi nt/72 + \partial_n)/72$. The sum of the absolute amounts of mass alterations per unit of time in 4 consecutive points, *i.e.* for the 18 harmonics, is therefore $2\pi/72\sum_{t=0}^{t=3} 18A18\ |\cos (2\pi \,.\, 18t/72 + 315°)|$, and this expression represents the maximum possible mass alteration per unit of time. The potential energy is therefore a minimum with the phase of 315° at the point $t = 0$. The theory is now extended to 24 harmonics and found to be generally valid. H. H. Ho.

1314. *Crystal Growth in Tubular Spaces.* **R. Gross** and **H. Möller.** (Zeits. f. Physik, 19. 5-6. pp. 375-387, 1923.)—Results are given of experiments on the growth of crystals of salol in the substance melted in tubes of various bores and radii of curvature. When a number of nuclei are present, a process of selection results in the continued development of only those crystals having their most favourable direction of growth corresponding with the axis of the tube. In straight tubes the crystalline axes mostly retain parallel positions, but occasionally the principal direction of growth suffers displacement by the next most favourable one.

As regards growth in curved tubes, three different types are possible. During the continued growth either the axes of the crystals remain parallel or sudden changes in their position occur. Moreover, growth independent of the crystal resulting from the seeding is also possible. The occurrence of one or the other of these three types is shown to depend on the extent of the supercooling, the dimensions and curvature of the tube, and the number of nuclei present. The cause of the formation of nuclei at the seeding place and in front of the growing crystal faces is regarded as the mechanical fracture of the crystal already present. T. H. P.

1315. *The Principle of the Specific Interaction of Ions.* **J. N. Brönsted.** (Am. Chem. Soc., J. 45. pp. 2898-2910, Dec., 1923.)—A further development of the above principle [see Abstract 1929 (1922)] which is re-stated as follows. "The ratio of the activity coefficients of the same kation in two equally strong solutions having an anion in common is a function only of the nature of the two kations of the solvents. And the ratio of the activity coefficients of the same anion in two equally strong solutions having an anion in common is a function of the nature of the anion considered and the kations of the two solvents." The terms "anion" and "kation" may, of course, be interchanged throughout. A further principle is enunciated, that of "the linear variation of the activity peculiarities," stated thus. "In a dilute salt solution the osmotic deviations of the solutions and the activity deviations of any ion from an ideal value is, at constant composition of the dissolved salt mixture, a linear function of its total concentration, and at constant total concentration of an isotopic mixture, a linear function of its composition." The expression "activity deviation" is defined as $\log_e (f/f_i)$ where f is the activity coefficient of the ion considered, and f_i the ideal one depending only on the type of salt and on the total concentration. Equations are deduced connecting the freezing-points of solvents with an ion in common, with the activity coefficient and solubilities of salts possessing the same common ion, which are identical with the equations deduced on the basis of the principle of the specific interaction of ions. Further elaboration leads to the conclusion that the activity coefficient of sodium chloride present in small amount in a solution of potassium chloride, is identical with that of potassium chloride present in small amount in a solution of sodium chloride of the same strength, this value being the geometric mean of the activity coefficients of the two salts in their own solutions. Recent work on activity coefficients is discussed, particularly "the principle of independent activity coefficients," put forward by Harned which is shown to lead to conclusions contradicted by experiment. Solubility measurements embracing a series of cobaltic-ammonia salts in solutions of sodium sulphate and sodium chloride have been carried out. The results are found in full agreement with the principle of the specific interaction. T. B.

1316. *Influence of Hydrogen Concentration on the Auto-Oxidation of Hydroquinone.* **V. K. la Mer** and **E. K. Rideal.** (Am. Chem. Soc., J. 46. pp. 223–231, Jan., 1924.)—The property of absorbing oxygen by hydroquinone in alkaline solution is common to many substances containing phenolic groups. The rate at which hydroquinone reacts with molecular oxygen was followed by shaking borate buffers 0·01 M. in respect to hydroquinone with oxygen. The rate does not become appreciable until the solution is more alkaline than pH 7·3 or 7·8 for air. The rate of reaction is highly sensitive to further increase of Sörensen values being proportional to the three halves power of the hydrogen-ion concentration for the region investigated. The complex formation of primary and secondary ions is suggested as an explanation of the mechanism of the reaction. F. J. B.

1317. *Photo-Electricity. Calorific Action of Radiation on Metals Plunged into Solutions of their Salts.* **G. Athanasiu.** (Comptes Rendus, 178. pp. 561–563, Feb. 4, 1924.)—Bouty has shown that the temperature coefficient of elements formed by metallic electrodes plunged into solutions of their salts is far from negligible. The contact metal-liquid acts as the elements of a thermoelectric junction of high sensitivity. A difference of temperature of one degree produces in the element $Zn\text{-}ZnSO_4\text{-}Zn$ an e.m.f. of about 800 micro-volts. The author, employing as source an arc of mercury in quartz, shows that a measurable calorific effect is produced. With the metals Hg, Pb, and their nitrates, it is shown that the e.m.f. produced is, within error of experiment, that which would be expected from the heat radiated by the source to the electrodes. There are in fact two effects, the first due to a chemical alteration of the surfaces of the electrodes, the second (which increases regularly with the duration of the illumination, and disappears slowly when the latter is suppressed) to the calorific energy of the radiation. In many cases the two effects mentioned are sufficient to mask completely any photoelectric effect that may be simultaneously produced. T. B.

1318. *Newer Aspects of Ionisation Problems.* **H. S. Taylor.** (Am. Electrochem Soc., Trans. 43. pp. 31–48; Disc., 48–50, 1923.)—A résumé is presented of some recent work by Born, Fajans, Haber, and others on the problem of energy changes accompanying the conversion of some solid crystalline substances and of the hydrogen halides into dissolved ions. An outline is given of the concepts of lattice energy and of the electron affinity of halogens, the quantitative side of the problem receiving detailed consideration. In the latter, small modifications of the earlier calculations have been made whenever newer material of a more reliable nature seemed to be available. Some of the lines along which progress may be anticipated have been indicated. AUTHOR.

1319. *Measurement of Oxidation Potentials at Mercury Electrodes. Part III. Ter- and Bi-valent Titanium.* **G. S. Forbes** and **L. P. Hall.** (Am. Chem. Soc., J. 46. pp. 385–390, Feb., 1924.)—A mixture of titanium dichloride and tri-chloride prepared by heating the metal in hydrogen chloride, is used for the measurement of e.m.f. against a mercury electrode at 0° C., air being displaced by carbon dioxide. The concentrations of ter- and bivalent titanium being determined, the e.m.f., calculated against a hydrogen electrode, is extrapolated to equal concentrations of both valencies. The dichloride decomposes rapidly in concentrated hydrochloric acid, the e.m.f. declining rapidly. In addition, the e.m.f. for tetravalent and bivalent titanium is calculated. B. W. C.

1320. *The Effect of a Magnetic Field on the Potential of Hydrogen Occluded in Iron.* **T. W. Richards** and **W. T. Richards.** (Am. Chem. Soc., J. 46. pp. 89–104, Jan., 1924.)—The application of a magnetic field to pure iron in a solution of ferrous sulphate results in an almost negligible decrease in potential. With hydrogen occluded in iron, there is a distinct lowering of potential proportional to the intensity of the magnetic field employed. This decrease of over-voltage is proportional to the over-voltage itself. The authors favour the view that the occluded hydrogen is in an atomic but not ionised condition; the magnetic field alters the texture of the metal and therefore the potential. The influence of ferrous, ferric, and hydrogen ion concentrations in the solution are considered in order to determine the best conditions for the experiments. B. W. C.

1321. *Electromotive Force Produced by the Action of Light on Metals Immersed in Solutions of their Salts.* **G. Athanasiu.** (Comptes Rendus, 178. pp. 386–388, Jan. 21, 1924.)—The author has extended his work on mercury electrodes [see Abstract 2317 (1922)] to electrodes of silver, copper, nickel, cadmium, and zinc. The e.m.f. produced depends on the time of standing and is due to the formation of a deposit on the surface of the electrode by chemical reaction. Similar results are obtained with non-reversible elements, such as the Daniell cell. B. W. C.

1322. *Hydrogen-Ion Concentration.* **E. Darmois.** (J. de Physique et le Radium, 4. pp. 461–491, Dec., 1923.)—The author reviews the present state of knowledge of the signification of hydrogen-ion concentration. The necessity for a quantitative measurement in each case studied is pointed out, the e.m.f. method being preferred to the use of indicators for this purpose. Both methods are considered in detail. The quinhydrone electrode is also discussed. Attention is drawn to the utility of the conception of an activity coefficient of the ions when dealing with strong electrolytes. Various applications of the measurement of *p*H values are quoted, with especial reference to biochemical processes which are dependent upon acidity, which is most accurately determined by means of *p*H value. B. W. C.

1323. *The Free Energy of Dilution and the Activity of the Ions of Hydrogen Iodide in Aqueous Solution.* **J. N. Pearce** and **A. R. Fortsch.** (Am. Chem. Soc., J. 45. pp. 2852–2857, Dec., 1923.)—The decrease in free energy and heat content accompanying the reaction in cells of the type H_2/HI(*c*), AgI/Ag is calculated for various concentrations of hydrogen iodide at 25° from measurements of the electromotive force. The free-energy decrease accompanying the transfer of one mol. of hydrogen iodide from various concentrations to 0·005 M is calculated, and the geometric mean activity coefficient of the ions. These are practically equal to the corresponding coefficients for hydrogen chlorine. This bears out the view of Lewis and Randall [see Abstract 230 (1922)] that the activity coefficients for the ions of strong electrolytes are the same in solutions of the same ionic strength. B. W. C.

1324. *The Hydrogen Electrode in Alkaline Solutions.* **A. H. W. Aten.** (Am. Electrochem. Soc., Trans. 43. pp. 89–98, 1923.)—When a hydrogen electrode, saturated with hydrogen, is in equilibrium with 0·1n HCl, it is in the same state of equilibrium with 1·0n HCl, and *vice versa.* This is not the case, however, when the solution of an alkali is used in place of an acid. When a hydrogen electrode in equilibrium with 1·0n NaOH is put in 0·1n NaOH, or the reverse, a considerable time period is required to reach a new equilibrium. The same phenomenon is observed in a more marked degree when the electrode is changed from 0·1n NaOH to 0·1n HCl, or the reverse. The explanation suggested is that the electrode must absorb Na or give it off, as the case may be, in order to reach an equilibrium with the final solution. AUTHOR.

1325. *Cuprous-Oxide Photo-Voltaic Cells.* **A. D. Garrison.** (J. Phys. Chem. 27. pp. 601–622, Oct., 1923.)—The subject is dealt with experimentally at some length. A cuprous-oxide electrode which, when illuminated, becomes positive with respect to a neutral solution may be made to become negative by increasing the density of the oxide coating. A cuprous-oxide coating is slowly formed on copper when it is left standing in a neutral solution for a long time in contact with air or oxygen, and as a result electrodes which have only a positive effect at first slowly develop the negative effect on contact with oxygen. The positive photo-potential is found to be approximately proportional to the logarithm of the light intensity and increases with increasing hydrogen-ion concentration. The maximum negative photo-potential is proportional to the light intensity for low intensities and constant at high intensities, while the positive recoil following the negative maximum increases with the intensity. The maximum negative photo-potential decreases with increasing ion concentration. The phenomena are explained by the assumption that the light shifts the equilibrium constant of the reaction, causing the cuprous oxide to behave as though its solubility were increased in the light. W. R. C.

1326. *Concentration Cells in Methyl Alcohol.* **J. Grant** and **J. R. Partington.** (Faraday Soc., Trans. 19. pp. 414–417; Disc., 418–419, Nov., 1923.)—Figures have been published by J. H. Wilson for concentration cells made up with solutions of silver nitrate in methyl alcohol. These figures do not show very good agreement with the results calculated from the Nernst equation. Cells were therefore made up by the authors, with careful precautions in preparing the methyl alcohol. The values obtained for the e.m.f. show good agreement with the values calculated.

W. R. C.

1327. *Volta-Luminescence.* **J. Lifschitz.** (K. Akad. Amsterdam, Proc. 26. 7–8. pp. 561–574, 1923.)—Experiments are described on the luminescence of electrodes when currents are passed through certain electrolytic cells. The luminescence was examined spectroscopically. When the metal so detected occurs only in the electrolyte, the spectrum resembles very closely that of the spark-spectrum of the metal, but if this metal is used as a kathode in pure acid a spectrum is obtained which agrees closely with the arc-spectrum. The view is taken that the kathode is surrounded by a gas envelope which contains hydrogen water-vapour and some oxygen, almost the whole fall of potential takes place in this layer, and as the kations are not able to traverse this layer a current of rapid kathode rays is formed which discharge these kations. The phenomena at the anode are much more numerous and more complicated than at the kathode. Besides gas layers there may be layers of solid substance between the electrolyte and electrode. The author considers that the origin of the luminescence is not chemical or due to reactions. If soluble anode products are formed luminescence seems never to be observed. W. R. C.

1328. *Application of the Contractometer to the Study of Nickel Deposition.* **E. A. Vuilleumier.** (Am. Electrochem. Soc., Trans. 42. pp. 99–107, Disc., 108–112, 1922.)—When nickel is deposited on thin sheets of metal the kathode bends towards the anode. The author has investigated this and similar phenomena by means of the contractometer [see Abstract 955 (1920)]; the peeling of nickel deposits is to be ascribed to the contraction of the nickel. The author concludes that the degree of contraction decreases as the deposit becomes more coarsely crystalline, but there are a number of factors such as temperature, *p*H, current-density, etc., which will affect the structure of the deposit. When only a little hydrogen is liberated during the deposition, delays or spurts in the contraction occur. Hydrogen, when electrolytically produced, causes the nickel to expand. Contraction is also observed during the deposition with silver, copper, and other metals. In the *discussion* the value of the contractometer in studying electro-deposition is emphasised, but some of the author's conclusions with regard to the structure of the deposit are considered unsound.

B. W. C.

1329. *Oxygen Overvoltage of Artificial Magnetite in Chlorate Solutions.* **H. C. Howard.** (Am. Electrochem. Soc., Trans. 43. pp. 51–53; Disc., 53–54, 1923.)—Attempts were made to oxidise sodium chlorate to perchlorate electrolytically at a magnetite anode. Negative results were obtained. The oxygen overvoltage of a magnetite anode in N sodium chlorate was measured and found to be from 0·4 to 0·6 volt lower than that of smooth platinum. AUTHOR.